A Dissertation on

Serum Magnesium level in critically ill patients

Submitted to

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In partial fulfilment of the Regulations
for the Award of the Degree of

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CERTIFICATE BY THE INSTITUTION

This is to certify that **Dr.G.VIJAYALAKSHMI,** Post - Graduate Student (June 2014 to April 2017) in the Department of General Medicine STANLEY MEDICAL COLLEGE, Chennai- 600 001, has done this dissertation on **"SERUM MAGNESIUM LEVEL IN CRITICALL ILL PATIENTS"** under my guidance and supervision in partial fulfillment of the regulations laid down by the Tamilnadu Dr. M. G. R. Medical University, Chennai, for M.D. (General Medicine), Degree Examination to be held in April 2017.

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DECLARATION

I, **Dr.G.VIJAYALAKSHMI,** declare that I carried out this work on **"SERUM MAGNESIUM LEVELS IN CRITICALLY ILL PATIENTS"** at the Intensive Medical Care Unit of Government Stanley Hospital . I also declare that this bonafide work or a part of this work was not submitted by me or any other for any award, degree, or diploma to any other university, board either in India or abroad.

This is submitted to The Tamilnadu DR. M. G. R. Medical University, Chennai in partial fulfilment of the rules and regulation for the M. D. Degree examination in General Medicine.

Dr.G.VIJAYALAKSHMI.

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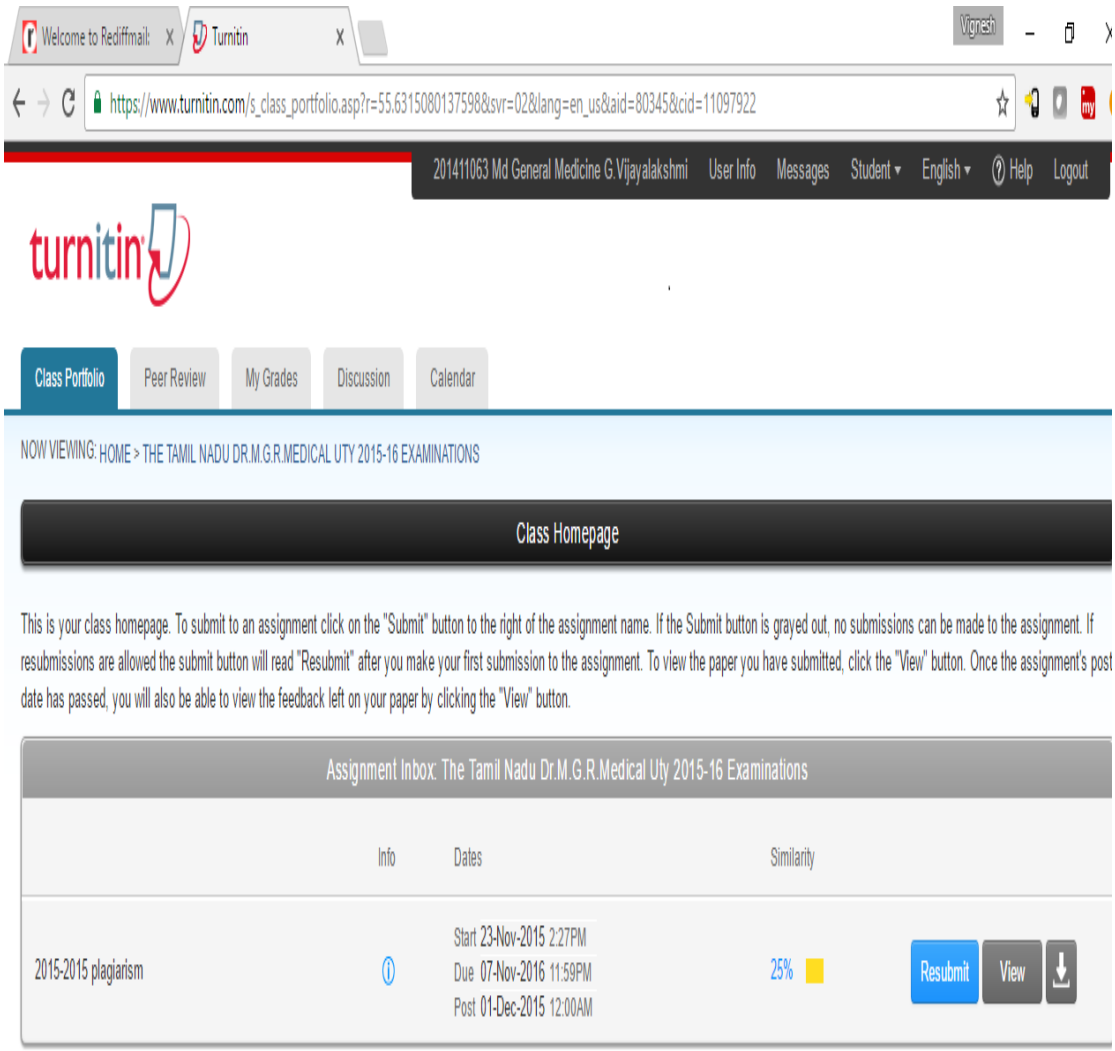
Dr. G. VIJAYALAKSHMI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INTRODUCTION

Magnesium is a very essential element of life and it is the second most abundant intracellular cation in the human body. Magnesium is known as fifth forgotten electrolyte. Intracellular Magnesium contributes to 99% of the total body Magnesium. Diet which consist of large amount of vegetables and fruits is a rich source of Mg. Excess intake of fibre and sugar will affect serum magnesium level. Magnesium absorption from gastrointestinal tract is influenced by taking excess fibre. By causing magnesiuria, excess sugar causes low serum magnesium level. Magnesium is primarily absorbed from the duodenum and the rectum and sigmoid colon can also absorb magnesium. Around 40% of the dietary magnesium is getting absorbed.

The body contains the total magnesium of around 21-28grams. 53% of total magnesium is found in bone, 19% in non muscular tissue and 1% in extracellular fluid. The majority of serum magnesium is bound to chelators such as ATP, ADP, proteins and citrate. Approximately 33% of serum magnesium is bound to proteins and 5-10% is not bound. In the regulation of intracellular magnesium, this unbound form play an essential role. In the regulation of serum magnesium kidneys play an important role. 60% of filtered magnesium is getting absorbed from the loop of Henle. So it is the major site for magnesium homeostasis. Only 120 mg of magnesium is excreted through urine as against 2400 mg of filtered magnesium.

Magnesium acts as cofactor for biochemical reactions that take place intracellularly. Transcription of nucleic acids, translation of mRNA, synthesis of proteins and also regulation of mitochondrial function need adequate Magnesium levels. Numerous immunological functions like activation and adherence of macrophages, granulocytes oxidative burst needed for bacterial killing and proliferation of lymphocytes depends on adequate magnesium levels.

When comparing to respective calcium salts, magnesium salts dissolve in water easily. So the availability of magnesium to organisms is easy. Magnesium is acting as a central ion in chlorophyll of plants. In vertebrates it is the 4^{th} most abundant cation and after potassium, it is the second most abundant intracellular cation. Both of them are considered as a vital elements for numerous physiological functions. The salts of magnesium are used in the form of magnesium hydroxide, magnesium citrate, magnesium sulphate or magnesium chloride, in laxatives or antacids.

Chemical characteristics of magnesium:

In the periodic table: it is a group 2 element.

Atomic mass: 24.305Da

Specific gravity at 20 degree C: 1.738

Boiling point: 1090 degree C

Melting point: 648.8 degree C

When comparing to potassium, sodium and calcium, it binds with hydration water tightly. So it is hard to dehydrate the hydrated magnesium, also the radius of hydrated magnesium is 400 times larger than that of dehydrated form. When compared to calcium, sodium and potassium, for the magnesium ions the difference between hydrated and dehydrated state is very prominent. Although ionic radius of dehydrated magnesium is small, it is biologically relevant. Lot of peculiarities of magnesium can be explained by the above simple fact including its antagonistic behaviour to calcium in spite of the similar charge and chemical reactivity. For example, unlike calcium which readily traverses through narrow channels in biological membranes, the magnesium cannot be able to do so. Because magnesium cannot be stripped of its hydration shell.

Physiological functions of magnesium:

In muscle contraction, by stimulating the calcium activated ATPase of the sarcoplasmic reticulum, the magnesium stimulates the calcium reuptake. Also magnesium modulates cell proliferation and insulin signal transduction. It is also important for cell adhesion and transmembrane conductance of calcium and potassium ions. By maintaining the conformation of nucleic acids, it is important for the structural function of proteins and mitochondria.

By observing high incidence of hypomagnesemia as well as low intracellular magnesium levels in diabetic patients, magnesium may have a role

in insulin secretion. Patients who have conceived at relatively young age ,suffered from hypomagnesemia during their pregnancy period. So the offspring might be affected through out their life.

Both calcium and magnesium are competing with one another for the same binding sites on plasma proteins. Also magnesium opposes the calcium dependent release of Ach at motor end plates. By doing this, it acts as a natural calcium antagonist. Calcium is considered as a powerful death trigger, but magnesium is not. Magnesium also inhibits calcium induced cell death.

Regulation of magnesium influx and efflux:

The intra and extracellular magnesium is being exchanged at various rates in myocardium, kidneys, skeletal muscles, brain and lymphocytes. In mammalian heart, adipocytes and kidney the total intracellular magnesium is completely exchangeable with extracellular magnesium within 3-4hours. But in man, this equilibrium takes place very slowly.

Magnesium consumption:

To prevent magnesium deficiency we should consume it regularly. Since the recommended daily allowance of magnesium varies**,** it is difficult to assess the exact intake of magnesium. Dose of more than 300 mg which should be adjusted for age, sex and nutritional status. Drinking water responsible for 10% of total daily magnesium intake. Green vegetables which is the richest

source for chlorophyll contribute to the major source of magnesium. Seeds, nuts and unprocessed cereals are also contribute to the rich source of magnesium. Fish, meat, fruits and legumes have an intermediate magnesium concentration. Diary products have low magnesium concentration. Processed foods have much more lower serum concentration when compared to unrefined grain products.

Magnesium absorption and excretion:

The intestine, bone and kidneys play a major role in magnesium homeostasis. Like calcium, magnesium gets absorbed in the gut & stored in bones, and excess of magnesium gets excreted mainly through kidneys and also small amount in faeces. Two transport mechanisms are there for the reabsorption of magnesium from the gut. They are

1. Passive para cellular mechanisms : these are driven by means of electrochemical gradient & solvent drag. The majority of magnesium is absorbed in the small intestine by this mechanism.

2. Minor fraction of Mg is absorbed via TRPM6 && TRPM7. These are members of long transient receptor potential channel family.

Only about 24- 76% of consumed magnesium is absorbed from the gut & the remaining amount is eliminated through faeces. The rate of absorption of Mg from the gut is directly proportional to serum magnesium levels, it does

not depend upon total Mg intake. If concentration of Mg is low inside the lumen, active trans cellular transport will take an upper hand.

Since serum magnesium concentration is maintained within normal range by its excretion through urine. In this way kidneys are crucial for magnesium homeostasis. Excretion of magnesium follows circadian rhythm & maximum excretion occurs during night. Under normal conditions approximately 2400 mg of magnesium is filtered by the glomeruli. 95% of the filtered dose of magnesium is immediately reabsorbed and 3-5% is excreted in the urine. The thick ascending limb of loop of Henle is the major reabsorption site for magnesium and another small percentage get reabsorbed in the distal tubule. In hypomagnesemic states, kidneys try to preserve magnesium. So renal excretion of magnesium is very low. In contrast in a state of excessive intake, magnesium gets rapidly excreted through kidneys.

Level of magnesium in the plasma play a crucial role in maintaining normal homeostasis. Hormones play only a minor role in maintaining serum magnesium levels.

Pathophysiology:

To diagnose hypomagnesemia, measurement of serum magnesium levels and 24 hours of urinary magnesium excretion are the most important laboratory tests.

Further step would be to perform magnesium retention test. The prevalence of hypomagnesemia is ranging from 9-65% among hospitalized patients, that too in intensive care units. Numerous factors may play a role for example insufficient intake of nutritional magnesium, drugs like digoxin, aminoglycosides, furosemide, cisplatin amphotericin B and cyclosporine. Hypomagnesemia also associated with chronic conditions like malignancy, CVA, cirrhosis and a number of other conditions. In conditions like acute pancreatitis, there is compartmental redistribution of magnesium.

Chronic hypomagnesemia: the following conditions are associated with chronic latent magnesium deficiency.

1. Atherosclerosis
2. Essential hypertension
3. Acute coronary syndrome
4. Renal calculi
5. Malignant tumours
6. Dyslipidemia
7. Psychiatric disorders and
8. Premenstrual syndromes.

Deficiency of Magnesium leads to activation of neuroendocrine pathways which induces systemic stress response, which in turn takes part in

the pathogenesis of numerous disease and also implicated in an increased mortality rate among ICU patients. The above said effects of Magnesium on immune system play a crucial role in the pathogenesis of sepsis. In hypomagnesemic state, cardiac tolerance to reduced oxygen level is reduced significantly. Electromechanical activities of cardiac smooth muscles and vascular endothelial cells can get affected largely by small changes in free Magnesium levels.

Normal serum magnesium levels in humans fall between 1.7-2.2mg/dl. Usually a serum level less than 1.7mg/dl is used as a reference for hypomagnesemia.

Clinical features of hypomagnesemia:

Early signs include nausea, vomiting, anorexia, easy fatigue and weakness. Other manifestations include agitation, tremors, fasciculations, depression, hypokalemia and cardiac arrthmias. In severe hypomagnesemia tingling, numbness, cramps, muscle contractions, seizures, sudden onset of altered behaviour caused by excess electrical activity of the brain, changes in personality, irregularities in heart beat and coronary spasm can occur. Other electrolyte imbalances such as hypokalemia and hypocalcemia may accompany severe hypomagnesemia.

Hypermagnesemia:

1. In maintaining magnesium homeostasis kidneys play a crucial role. So in chronic renal failure, the compensatory mechanisms become inadequate and results in hypermagnesemia.

2. Antacids and laxatives which contain magnesium when used therapeutically especially in elderly patients and in combinations they are more prone to develop hypermagnesemia.

3. Iatrogenic hypermagnesemia in pregnancy- magnesium infusion used for the treatment of eclampsia.

4. Excessive ingestion of magnesium has been reported in people who have near drowned in dead sea.

Clinical features of hypermagnesemia:

1. Nausea, vomiting, cutaneous flushing and hypotension are associated with moderate hypermagnesemia.

2. Neuromuscular dysfunction ranges from drowsiness to respiratory depression, areflexia, hypotonia or even coma can occur in a higher concentrations.

3. Cardiac manifestations include bradycardia, nonspecific ECG changes like prolonged PR interval, QRS and QT interval, 3rd degree AV block, atrial fibrillation and in advanced cases even asystole may occur.

ICU scoring systems:

It consists of 2 parts- a severity score, which is a number (generally the higher this is, the more severe the condition) and a calculated probability of mortality.

Classification of scoring systems:

Anatomical scores: depend on the anatomical area involved. Mainly used for trauma patients. Eg-abbreviated injury score (AIS) and injury severity score (ISS).

Therapeutic weighted score: based on the assumption that very ill patients require more complex interventions and procedures than patients who are less ill. Eg – the therapeutic scoring intervention system (TISS).

Organ specific score: similar to therapeutic scoring; the sicker a patient the more organ systems will be involved, ranging from organ dysfunction to failure. Eg- sequential organ failure assessment (SOFA).

Physiological assessment: based on the degree of derangement of routinely measured physiological variables. Eg- acute physiology and chronic health evaluation (APACHE) and simplified acute physiology score (SAPS).

Simple scales: based on clinical judgement. Eg- survive or die.

Disease specific: eg Ranson's criteria for acute pancreatitis, subarachnoid haemorrhage assessment using the World Federation of Neurosurgeons score and Liver failure assessment using Child-Pugh or Model for End Stage Liver Disease (MELD) scoring.

Types of scoring system:

First day scoring systems:

- APACHE scoring systems
- SAPS (simplified acute physiology score)
- MPM (mortality prediction mode)

Repetetive scoring systems:

- OSF (organ system failure)
- SOFA (sequential organ failure assessment)
- ODIN (organ dysfunction and infection system)
- MODS (multiple organ dysfunction score)
- LOD (logistic organ dysfunction)

The ideal scoring system:

- On the basis of easily/routinely recordable variables
- Well calibrated

- A high level of discrimination
- Applicable to all patient population
- Can be used in different countries
- The ability to predict functional status or quality of life after ICU discharge.

Several scoring systems have been developed to grade the severity of illness in critically ill patients. These systems are moderately accurate in predicting individual survival. However, these systems are more valuable for monitoring quality of care and for conducting research studies because they allow comparison of outcomes among groups of critically ill patients with similar illness severity. The most common system is the Acute Physiologic Assessment and Chronic Health Evaluation II (APACHE II) score introduced in 1985. It is a disease specific scoring system. It is the best known and most widely used score with good calibration and discrimination It generates a point score ranging from 0 to 71 based on 12 physiologic variables, age, and underlying chronic health score. The score is calculated within 24 hrs of admission. During the stay, it is not recalculated. If the patient gets readmitted, a new APACHE II score will be calculated. By definition it is an admission score. The score is directly proportional to the death rate. It is sum of acute physiology score, age and chronic health score.

12 physiological variables that are measured in APACHE II:

1. Core body temperature
2. Heart rate
3. MAP (mean arterial pressure)
4. Respiratory rate
5. Arterial pH
6. PaO2 or AaDO2 (depends on FiO2)
7. Serum sodium
8. Serum Potassium
9. Creatinine
10. Packed cell volume
11. Total WBC count
12. Glascow Coma Scale.

APACHE II score calculation is not applicable if

1. Age at admission < 16yrs,
2. Primary burns,
3. Admission after CABG surgery,

4. Patient is transferred from another ICU,

5. All 12 physiological variables are missing.

Although APACHE II is the oldest scoring system, still it is most widely used among others. Because the data need for its calculation are reproducible, simple, well defined and can be collected on a routine basis.

Other scoring systems:

SAPS II score is used to provide a predicted mortality. It does not reflect the expected mortality.

SOFA has been designed to provide a simple daily score. It gives the idea that how the status of the patient is evolving over time.

Glascow Coma Scale is designed to assess the status of the central nervous system. It can also be used as the part of other scoring systems.

RIFLE- Risk, Injury, Failure and end stage kidney classification. It comprises 3 severity levels(risk, injury, and failure) and 2 possible outcomes(loss & end stage)

Child-Pugh score has been used for liver failure. It can be used for ward patients also.

Ranson score is a simple score used for pancreatitis patients.

MODS- Multiple Organ Dysfunction Score which is similar to SOFA score.

LODS- Logistic Organ Dysfunction System: it is used as a admittance score, not used for monitoring the patient.

The critically ill patient is defined as, the one who is at imminent risk of death. The measures should be taken to assess the severity of illness as early as possible and appropriate measures should be taken promptly to assess, diagnose and manage the illness. **The critical illness is defined as** any disease process which leads to physiological instability leads to disability or death within minutes or hours.

Criteria for ICU admission:

- Critically ill who is in a medically unstable state.
- Patients who require intensive monitoring, also at times may require emergency interventions.
- The patient who is not going to recover because of their severity of illness.
- Patients who are not eligible for ICU admission but who are not expected to survive.

Warning signs of severe illness:

- Systolic blood pressure <90 or Mean arterial pressure < 60mm hgient
- Glascow coma scale<12
- Heart rate >150 or <50 beats per minute
- Respiratory rate >30 or <8 per minute
- Urine output <0.5ml/kg/hour

ABCED approach of critically ill patient:

- Airway
- Breathing
- Circulation
- Disability
- Exposure

ABCED approach: Airway

Causes for airway obstruction:

- Infection
- Inflammation
- Laryngospasm
- Bronchospasm

- Blood
- Vomitus
- Foreign body
- CNS depression
- Trauma
- Compression

Causes for breathing problem:

- Lung disorders: Pneumothorax, Haemothorax, Infection, Acute exacerbation of COPD, Bronchial asthma, Pulmonary embolism, ARDS.
- Decreased respiratory effort: Muscle weakness, Nerve damage, Restrictive diseases of chest, Pain from fractured ribs.

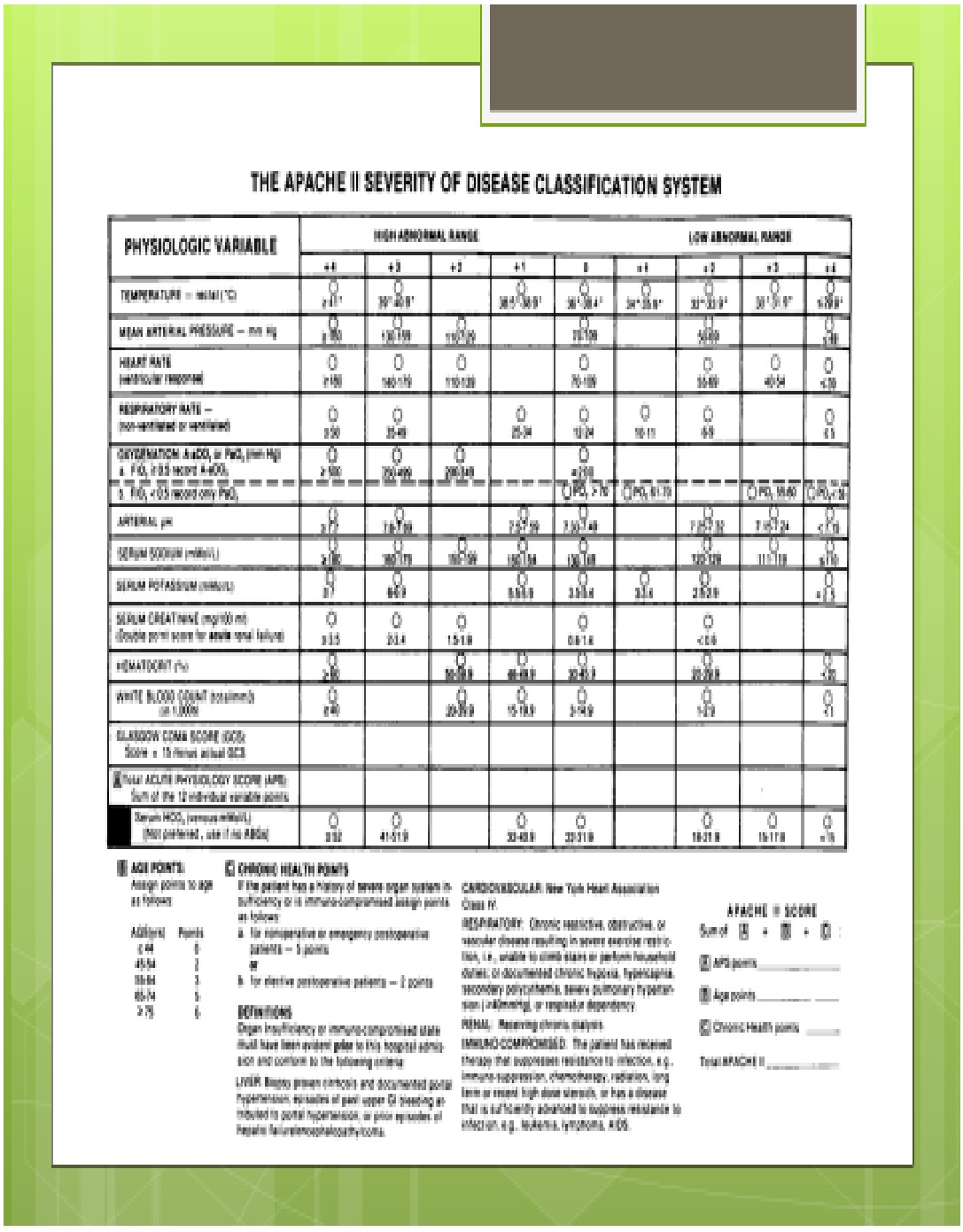
Causes for circulation problem:

- Primary causes: Acute coronary syndromes, Arrhythmias, Hypertensive heart disease, Valve disease, Heriditary cardiac disease, Drugs, Electrolytes/ acid base abnormalities.
- Secondary causes: Asphyxia, Blood loss, Hypoxemia, Hypothermia, Septic shock.
-

Complications:

- Arterial- haemorrhage, clotting, neurovascular compromise.
- Pulmonary embolism

APACHE II SCORE – TABLE



THE APACHE II SEVERITY OF DISEASE CLASSIFICATION SYSTEM

PHYSIOLOGIC VARIABLE	HIGH ABNORMAL RANGE					LOW ABNORMAL RANGE			
	+4	+3	+2	+1	0	+1	+2	+3	+4
TEMPERATURE – rectal (°C)	≥41°	39°–40.9°		38.5°–38.9°	36°–38.4°	34°–35.9°	32°–33.9°	30°–31.9°	≤29.9°
MEAN ARTERIAL PRESSURE – mm Hg	≥160	130–159	110–129		70–109		50–69		≤49
HEART RATE (ventricular response)	≥180	140–179	110–139		70–109		55–69	40–54	≤39
RESPIRATORY RATE – (non-ventilated or ventilated)	≥50	35–49		25–34	12–24	10–11	6–9		≤5
OXYGENATION: A-aDO$_2$ or PaO$_2$ (mm Hg) a. FIO$_2$ ≥ 0.5 record A-aDO$_2$	≥500	350–499	200–349		<200				
b. FIO$_2$ < 0.5 record only PaO$_2$					PO$_2$ > 70	PO$_2$ 61–70		PO$_2$ 55–60	PO$_2$ < 55
ARTERIAL pH	≥7.7	7.6–7.69		7.5–7.59	7.33–7.49		7.25–7.32	7.15–7.24	<7.15
SERUM SODIUM (mMol/L)	≥180	160–179	155–159	150–154	130–149		120–129	111–119	≤110
SERUM POTASSIUM (mMol/L)	≥7	6–6.9		5.5–5.9	3.5–5.4	3–3.4	2.5–2.9		≤2.5
SERUM CREATININE (mg/100 ml) (Double point score for acute renal failure)	≥3.5	2–3.4	1.5–1.9		0.6–1.4		<0.6		
HEMATOCRIT (%)	≥60		50–59.9	46–49.9	30–45.9		20–29.9		≤19
WHITE BLOOD COUNT (total/mm3) (in 1,000's)	≥40		20–39.9	15–19.9	3–14.9		1–2.9		≤1
GLASGOW COMA SCORE (GCS) Score = 15 minus actual GCS									
A. Total ACUTE PHYSIOLOGY SCORE (APS) Sum of the 12 individual variable points									
Serum HCO$_3$ (venous mMol/L) (Not preferred, use if no ABGs)	≥52	41–51.9		32–40.9	22–31.9		18–21.9	15–17.9	≤15

B. AGE POINTS

Assign points to age as follows:

Add (pts)	Points
≤ 44	0
45–54	2
55–64	3
65–74	5
≥ 75	6

C. CHRONIC HEALTH POINTS

If the patient has a history of severe organ system insufficiency or is immunocompromised assign points as follows:

a. for nonoperative or emergency postoperative patients – 5 points

or

b. for elective postoperative patients – 2 points

DEFINITIONS

Organ insufficiency or immunocompromised state should have been evident prior to this hospital admission and conform to the following criteria:

LIVER: Biopsy proven cirrhosis and documented portal hypertension, episodes of past upper GI bleeding attributed to portal hypertension, or prior episodes of hepatic failure/hepatoencephalopathy/coma.

CARDIOVASCULAR: New York Heart Association Class IV.

RESPIRATORY: Chronic restrictive, obstructive, or vascular disease resulting in severe exercise restriction, i.e., unable to climb stairs or perform household duties; or documented chronic hypoxia, hypercapnia, secondary polycythemia, severe pulmonary hypertension (>40mmHg), or respirator dependency.

RENAL: Receiving chronic dialysis.

IMMUNOCOMPROMISED: The patient has received therapy that suppresses resistance to infection, e.g., immunosuppression, chemotherapy, radiation, long term or recent high dose steroids, or has a disease that is sufficiently advanced to suppress resistance to infection, e.g., leukemia, lymphoma, AIDS.

APACHE II SCORE

Sum of A + B + C:

A. APS points _____

B. Age points _____

C. Chronic Health points _____

Total APACHE II _____

Among patients admitted in ICU, 80% of them survive and recover within a short period. However, a subgroup do not recover sufficiently to become independent within a short period of time and they recover slowly since then. These patients are defined as **chronically critically ill patients.**

The above said patients are irrespective of the definition, they suffered from repeated episodes of infection and shock during their ICU stay. So chronic critical illness is not an extension of an acute critical illness. It is a complex syndrome characterised by a combination of immunological, metabolic, neuroendocrine and neuropsychiatric manifestations.

In my study I have tried to correlate between serum Mg levels, APACHE II scoring in critically ill patients in relation to the duration of ICU stay, to assess the need for ventilator support as well as duration and the final outcome whether discharge or death.

AIM

To study the level of Serum Mg in critically ill patients admitted in Intensive medical care unit and correlating the outcome with APACHE II scoring.

MATERIALS AND METHODS

I have done a prospective observational study in 100 critically ill patients admitted in a Intensive medical care unit, Government Stanley Medical College & Hospital during the period of March 2016 to September 2016. Acute Physiology And Chronic Health Evaluation (APACHE II) score have been calculated for each patient on the day of admission to Intensive care unit. Critically ill adult patients aged more than 18years were included.

Written and informed consent was obtained from all patients. Patients who had received blood products, magnesium or calcium infusions before sampling have been excluded from the study. Inclusion of the patients in this study did not affect the routine patient care in the IMCU. Venous blood samples of around 4.5ml was taken to assess serum magnesium levels, within the first 24hours of admission in to the IMCU.

Patient details recorded were:

Age,

Gender,

Presenting symptoms and signs,

Diagnosis,

Relevant investigation reports,

Treatment,

Duration of stay in IMCU,

Any complications thereof,

Use of mechanical ventilation and its duration.

Patients were followed up till discharge or death. The final analysis is made at the end of the study to achieve the aforementioned goals.

Inclusion criteria:

1.Critically ill adult patients above the age of 18 years, admitted in IMCU.

2. with APACHE II score of 18 or more.

Exclusion criteria:

1.Patients who had received blood products.

2.Patients who had received magnesium infusion.

3. Patients who are not willing to participate in this study.

REVIEW OF LITERATURE

1.Sunil Kumar et al, conducted a prospective observational study in 115 elderly patients of more than 60 years admitted in the Intensive Care Unit and correlated between Serum Magnesium levels and the duration of ICU stay, need for mechanical ventilation and its duration, and the final outcome about discharge or death.

They concluded that among the elderly patients admitted in ICU, 59.30% had low serum magnesium levels. Hypomagnesemic patients, when compared with normomagnesemic patients had no correlation with duration of ICU stay .But the necessity for mechanical ventilation, average duration of ventilation and death rate were higher in hypomagnesemic patients when compared to normomagnesemic individuals. Low serum magnesium levels were associated with mild increase in mortality rate. Need as well as the duration of mechanical ventilation were also higher , but they did not have statistical significance. Also the duration of ICU stay was not affected by hypomagnesemia. So serum magnesium level monitoring may have impact on prognostic and therapeutic implications especially in elderly patients.

Magnesium requirements are affected particularly in elderly patients by the following three factors. They are 1. Dietary factors for example poor intake of food, intake of processed food, high sugar and fiber. 2. Host factors for example chronic disease, anabolic or catabolic state, reduced intestinal

absorption, ischemia, excess excretion through kidneys and consumption of alcohol. 3. Environmental factors for example stress and medications (antibiotics, purgatives, diuretics and cardiac drugs). They didn't conduct a detailed survey in their study to find out the exact cause for hypomagnesemia. It may be multifactorial.

Among hospitalized, elderly critically ill patients, disorders of Magnesium is the frequently unrecognized electrolyte disturbance. The incidence of hypomagnesemia varies among general population and hospitalised patients. It is around 2% in general population, 10- 20% among hospitalized patients and 50- 60% among ICU patients, 30- 80% in alcoholics and 25% in diabetic patients treated as outpatients.

In their study they tried to point out the possible impact of serum magnesium levels in critically ill elderly patients, on outcomes in whom age itself is a comorbid condition. In their study group of 172 critically ill elderly patients, 102 (59.30%) were hypomagnesemic. So hypomagnesemia is the frequent occurrence in critically ill elderly patients.

There are multiple studies to show the relationship between hypomagnesemia and morbidity& mortality. In general the mortality rate was high among hypomagnesemic patients irrespective of their age, when compared to patients having normal serum magnesium levels, as reported by Kumar et al (38.56% vs. 14.73%), Limaye et al (57% vs 31%), Safavi and

Honarmand (55% vs. 35%), and Rubeiz et al(46% vs.25%). The study conducted by Sunilkumar et al in critically ill elderly patients revealed that in hypomagnesemic patients the mortality rate is high (39.21%) when compared to normomagnesemic group (28.57%).

2. Henk.J.Hujjgen et al, conducted a study in 115 critically ill patients about the relationship between Total and ionized Magnesium level, Serum Albumin levels and the role of extracellular and intracellular Magnesium in outcome prediction. They measured the levels of serum total and ionized magnesium and serum albumin and correlated with the APACHE II score and 1-month mortality. Among them 51.3% showed the concentration of serum total Mg below the reference range. Among those 71% showed normal level of serum ionized Mg and none of them showed low intracellular Mg levels. They concluded in their study that observation of low serum Mg level in critically ill is based on which fraction of Mg is measured and also poor correlation between serum Mg and clinical outcome suggest that hypomagnesemia is merely an epiphenomenon. By means of direct measurement we can obtain fairly reliable concentration of ionized Mg rather than by indirect calculation from serum albumin and serum total Mg. The above said study was undertaken to know the relationship between the levels of total and ionized serum magnesium and albumin (which is the most important binding protein of magnesium in blood) levels in critically ill patients and what is the role of intra and extracellular magnesium to predict the outcome, which is expressed as the

Acute Physiology And Chronic Health Evaluation (APACHE II score) and 1 month mortality in those critically ill patients.

In their study, the positive predictive value of hypomagnesemia for a bad clinical outcome (1 month mortality and APACHE II score of more than 20) was 50% or less for all measured magnesium parameters. Only the calculated parameter friMg2+ had a positive predictive value of more than 50%.

3. Safavi had done a retrospective study in which he took serum Mg levels in 100 patients admitted in ICU. Among them who developed hypomagnesemia during their hospital stay, had higher SOFA and APACHE scores during their admission and high mortality rate. He concluded in his study that serum Mg level monitoring may have both therapeutic as well as prognostic implications.

4.H.S.Kiran et al had done a prospective study in 150 critically ill patients in an ICU of JSS Hospital, Mysore. Blood was taken for serum Mg and pertinent investigations within 24hrs of admission. Patient were monitored till discharge or death. On the day of admission 63% were normomagnesemic, 30% were hypomagnesemic and 7% had hypermagnesemia. Hypomagnesemic patients when compared with normomagnesemic individuals they had higher mortality rate (51% vs 36%), higher APACHE II score on admission (24.13 vs 22.47), need of ventilator support was more frequent (35% vs 17%), a more

frequent hypocalcemia (49% vs 31%), a more frequent hypoalbuminemia (62% vs 51%), and a more frequent septicaemia (47% vs 21%). Patients with diabetes, hypertension and alcoholics had hypomagnesemia more frequently. No significant association between hypomagnesemia and arrhythmias, neurological manifestations, duration of stay, potassium disturbances, other electrolyte abnormalities, creatinine levels, metabolic acidosis and anemia.

Most of the studies done earlier measured only the total serum magnesium levels. Since the ionized magnesium is the metabolically active one, measurement of ionized magnesium gives better idea about the association between low serum magnesium levels and motality, morbidity in critically ill patients. In their study, they also found that there is an increased APACHE II score in hypomagnesemic patients. So hypomagnesemia is also associated with high APACHE II score and increased mortality rate. Also hypomagnesemia associated with an increased need for mechanical ventilation. Safavi and Honarmand and Limaye et al also showed statistically significant difference in need of ventilator support($p<0.05$). Their study also showed that among hypomagnesemic patients, the incidence of hypocalcemia was high. Safavi, Honarmand and Limaye et al also showed similar association. In their study, there were no potassium abnormalities. Limaye et al also did not find any association whereas Safavi and Honarmand, showed greater incidence of hypokalemia ($p<0.05$).

There are no definite guidelines for magnesium correction. According to Kevin J. Martin et al, the correction is recommended in severe (<1mEq/L in the serum) and symptomatic hypomagnesemia. Patients in whom the serum magnesium is mildly reduced (between 1 and 1.5 mEq/L) and in asymptomatic patients, the significance of hypomagnesemia and hence the correction of hypomagnesemia is not clear.

They have concluded that there is an association between low serum magnesium levels with high APACHE II and high mortality. Hypomagnesemic patients needed more frequent ventilator support. There was a statistically significant association between hypomagnesemia and the following parameters, hypocalcemia, hypoalbunemia, septicaemia, diabetes and hypertension. There was no relation between hypomagnesemia with arrhythmia, neurological manifestations, duration of stay, potassium disturbances, other electrolyte abnormalities, creatinine levels, metabolic acidosis, ionotropic use, type of diet and anemia. Whether hypomagnesemia in critically ill is a significant abnormality in itself contributing to the causality of complications, which needs to be corrected or is it just an insignificant association without any implications is difficult to ascertain.

5. Dimitrios Velissaris et al conducted a literature search in MEDLINE database (January 1980 to March 2015), the Cochrane Central Register of Controlled Trials (fourth quarter, 2014) and Embase (January 1980 to December 2014), using the terms magnesium, sepsis, hypomagnesemia and

critically ill. In many studies, the prevalence of hypomagnesemia is high among critically ill ICU patients and it was associated with sepsis and increased mortality in critically ill sepsis patients.

In one prospective observational study conducted on 100 ICU patients by Limaye et al revealed that 52% of patients had low serum magnesium levels, 41% had normal serum magnesium levels and 7% had high serum magnesium levels on admission. Patients with low serum magnesium levels need mechanical ventilation more frequently (73% vs 53%, $p<0.05$), the duration of mechanical ventilation is also more (4.27+or-5.01days vs. 2.15+or-3.36 days, $p<0.05$), high incidence of sepsis (38% vs 19%, $p<0.05$) and higher mortality (57.7% vs 31.7%, $p<0.05$) as compared to patients with normal serum magnesium levels.

Reinhart et al, while conducting a observational study on 102 medical ICU patients found that 20% of them had hypomagnesemia, and 9% had hypermagnsemia. Also among all ions, magnesium had the highest prevalence of abnormal values.

Another prospective observational study by Limaye et al in 100 ICU patients revealed that, 52% of patients had low serum magnesium levels, 41% of patients had normal serum magnesium levels and 7% had high serum magnesium levels. In his study, he found that when compared to patients with normal serum magnesium levels, hypomagnesemic patients need mechanical

ventilation more frequently(73%(38 of 52) vs.53% (22 of 41), P< 0.05), the duration of mechanical ventilation is also longer (4.27+ or – 5.01 days vs. 2.15 + or – 3.36 days, p<0.05), increased rate of sepsis among hypomagnesemic patients (38% (20 of 52 patients) vs.19% (8 of 41 patients), p<0.05) and increased rate of mortality(57.7% (30 of 52 patients) vs.31.7% (13 of 41 patients), p<0.05).

Likewise, two more recent large studies conducted in India and China also proved association between hypomagnesemia and outcome. In a prospective observational study conducted in 601 medical ICU patients, 25% of them had low serum magnesium levels on admission. It was associated with longer MICU stay (5.46 +or- 5.75 days vs.3.93+ or-3.88 days, P=0.0002), need for mechanical ventilation (56.86% vs. 24.33% P<0.0001) and mortality (38.56% vs. 14.73%, P<0.0001), but it was not associated with the duration of mechanical ventilation.

Another prospective observational study by Santos et al in 54 AIDS patients who suffered from acute kidney injury during their hospital stay. In their study, the following factors are associated with non recovery of renal function and with increased mortality, they are ICU admission, sepsis, dialysis and hypomagnesemia. Hypomagnesemia was the only factor associated with both non recovery of renal function(OR:6.945,95% CI:1.207=39.958, P=0.03) and with death(OR:6.923,95% CI:1.174=40.807,P=0.023) in multivariate

logistic regression but it is not clear, if hypomagnesemia is a determinant or simply a marker of illness severity in AIDS patients.

Chernow et al conducted a study in 193 ICU patients. They measured serum magnesium levels and found among 193 patients 117 (61%) had low serum magnesium levels. Also patients who had severe hypomagnesemia (defined as serum magnesim levels < or – to 1mEq/dl) also had hypokalemia, they received aminoglycosides more frequently and when compared to normomagnesemic patients mortality rate is also high among hypomagnesemic patients. So measurement of serum magnesium levels in patients who received aminoglycoside therapy is essential. If serum magnesium levels less than or equal to 1, replacement of magnesium may be needed.

Dabbagh et al did a prospective observational study in 2006 among 71 ICU patients, 41 out of 71 patients (60%) had low serum magnesium levels. Univariate analyses revealed that among patients who had received supplementation of Mg more than 1g/day, occurrence of arrhythmias, duration of ICU stay, the duration of mechanical ventilation, APACHE II scores were significantly lower compared with patients who had received magnesium less than 1g/day. Since the supplementation of magnesium more than 1g/day significantly reduces the mortality, they suggested an aggressive ICU supplementation protocol.

Moskowitz et al did a retrospective study in 8922 patients admitted to a 77 bed ICU over 8 years. They studied the relationship between hypomagnesemia and lactic acidosis. In their study 22.6% of patients were hypomagnesemic and they had lactic acidosis as well. So they suggested that hypomagnesemia is a correctable risk factor for lactic acidosis in critically ill patients.

Soliman et al conducted prospective observational study in 446 patients admitted to a University hospital ICU over a period of 3 months. On the day of admission 18% had ionized hypomagnesemia, 14% had ionized hypermagnesemia and 68% had normal ionized magnesium levels. Length of the stay in ICU and mortality had no association with low serum magnesium level. But patients with low serum ionized magnesium had higher rate of septic shock (57% vs 11%, $p<0.01$) and high mortality rate (35% vs 12%, $p<0.01$). Low serum ionized magnesium has associated with diuretic use, increased incidence of sepsis and worse outcomes. So they concluded that monitoring of ionized magnesium levels may have prognostic as well as therapeutic implications.

Cojocaru et al conducted study in sepsis patients and found that patients with acute bacterial infection (bronchopneumonia and urinary tract infection) had significant low levels of serum magnesium concentrations. These changes in magnesium were not related to the type of bacteria causing the infection and not associated with disease severity. So they concluded that the measurement

of serum magnesium levels is useful in bacterial infections. So it is better to have a high index of suspicion of hypomagnesemia in bacterial infections and should treat promptly.

Dimitrios Velissaris et al finally concluded that hypomagnesemia is common in sepsis patients who get admitted in wards as well as in ICU. It is very important to know about the principles and practice of fluid and electrolyte pathophysiology for providing optimal care to the patients. Identification of hypomagnesemia and its correction is very essential because associated increased in morbidity as well as mortality in hypomagnesemic critically ill patients.

6.Rubeiz et al conducted a prospective observational study in a total of 381 acutely ill patients admitted in an emergency department and consecutively shifted to medical ward and medical ICU of a tertiary care teaching hospital. On the day of admission concentration of serum magnesium and other metabolic variables were measured. Acute Physiology And Chronic health evaluation (APACHE II) scores were calculated for all patients. The mortality rate was determined among normomagnesemic as well as hypomagnesemic patients.

In their study, both hypomagnesemic and normomagnesemic group of patients had comparable APACHE II scores and other metabolic variables. But the mortality rate for hypomagnesemic patients both in the ward and medical

ICU was approximately twice ($p<.01$) when compared to normomagnesemic patients. Other metabolic abnormalities like hypokalemia and hypocalcemia had been observed equally in both hypomagnesemic and normomagnesemic patients. So they concluded that low serum magnesium level in acutely ill medical patients those admitted in both medical wards and ICU is associated with high mortality rate.

7.W.H.Linda Kao, MHS et al studied about the association between the risk of developing type 2 diabetes and low serum magnesium levels. They measured fasting serum magnesium levels and categorize it into 6 levels and dietary magnesium intake and categorize it into quartiles at baseline examination. They did their study in a cohort of nondiabetic middle aged adults and defined the incident type 2 diabetes cases as following

- self report of physician diagnosis,
- Use of anti diabetic medications,
- Fasting blood sugar values of 126mg/dl (7.0mmol/L), or
- Random blood sugar of 200mg/dl (11.1mmol/L)

Their results – there were graded inverse relationship between serum magnesium levels and incident type 2 diabetes among white participants. The incidence rate is increased to 2 fold from the highest to lowest serum magnesium level. In contrast among black participants no association was

found between serum magnesium levels and incident type 2 diabetes. Also there was no association between the dietary intake of magnesium and the incident type 2 diabetes both in black or white population.

They concluded that among white participants hypomagnesemia is a strong as well as independent predictor of incident type 2 diabetes. Since low dietary magnesium intake does not have any association with incident type 2 diabetes, compartmentalization and handling of magnesium by kidneys may play an important role in the relationship between hypomagnesemia and the risk for type 2 diabetes.

9.Keith W. Muir et al conducted a randomized, double blind placebo-controlled pilot trial in acute stroke patients by using intravenous magnesium sulphate.

Background of the study: magnesium acts as endogenous vasodilators in the cerebral circulation. By acting as an endogenous voltage-sensitive blockers, it antagonises N-methyl D aspartate receptor.

Methods: 60 patients who were diagnosed as middle cerebral artery stroke were randomized to magnesium sulphate or placebo within twelve hours od admission. Pulse rate, blood pressure and serum magnesium levels were monitored. The final outcome was either death or significant functional impairment at the end of 3 months.

Results of the study: Patients who had received magnesium had no significant adverse effects no change in BP or pulse rate. Laboratory parameters and echocardiographic findings didn't differ significantly between placebo and magnesium received groups. Serum magnesium was rising from 0.76mmol/L to 1.42mmol/L over twenty four hours and remained significantly elevated than placebo group at forty eight hours. Among patients treated with magnesium 30% were dead or disabled. Among placebo group 40% were dead or disabled at 3 months. The group who received magnesium, there was a decrease in the number of early deaths.

Conclusions: after acute stroke, patients are well tolerated the magnesium sulphate. It has no deleterious hemodynamic effects. Anyway further trials are required to determine the efficacy of the drug.

10. Jasmine Amighi et al conducted a prospective study- prediction of neurological events in advanced atherosclerotic patients with low serum magnesium levels. They selected 323 patients who have symptomatic peripheral artery disease and intermittent claudication. Serum magnesium was measured at the onset of study and they were followed up for 20months. Any occurrence of neurological events which is defined as either ischemic stroke and/or carotid revascularisation. To assess the relationship between serum Mg and neurological events, multivariate analysis was applied.

Results: among the study group, 35 patients(11%) had neurological events. While comparing patients with serum magnesium levels of >0.84mmol/L with patients who had serum magnesium levels of <0.76mmol/L, patients who had low serum magnesium levels exhibited 3.29 fold increased adjusted risk for neurological events. But patients who had serum magnesium levels between 0.76- 0.84mmol/L had no increased risk for neurological events.

Conclusion: In patients with symptomatic peripheral arterial disease, presence of hypomagnesemia has increased risk for neurological events. So substitution of magnesium in those patients with advanced atherosclerosis has a beneficial effect.

11. Seyed Ali Javad Mousavi et al conducted a historical cohort study in MICU of Hazrat e Rasool Hospital in 273 critically ill patients over a period of one year. To identify significant independent risk factors for mortality in ICU, binary logistic regression analysis were performed among the study group. Among patients who were enrolled in this study, 147 patients(53.8%) had normal serum magnesium levels and 126 patients (46.2%) had either hypo or hypermagnesemia. Patients who had low serum magnesium levels, when compared with normomagnesemic group had longer duration of mechanical ventilation as well as longer duration of ICU stay. Patients with abnormal serum magnesium values showed increased mortality rate. Three factors that determine the predicted probability of mortality in ICU set up were

1. Age,

2. Serum Mg and

3. Mechanical ventilation.

They concluded that monitoring of serum magnesium levels may have both prognostic and therapeutic implications. Always we should suspect high incidence of hypomagnesemia in ICU patients. Approximate incidence of hypomagnesemia in

- Medical ICU patients-65%
- Surgical ICU patients- 90%
- Hospitalized patients- 40%
- Postoperative patients- 60%

Isfahan by Safavi et al had done a retrospective study on 100 patients. On the day of admission, 51% had low serum magnesium levels. They exhibited significant difference in mortality rate (55% vs 33%) and the length of ICU or hospital stay when compared with normomagnesemic group.

Markgraf et al have concluded that APACHE II, APACHE III and SAPS II all have good discriminating power and among them APACHE II has the best calibration. Patients admitted in an ICU and diagnosed as sepsis most

commonly encounter fluid and electrolyte abnormalities. Mechanisms involved are 1. Reduction in glomerular filtration secondary to hypovolemia and hypotension which in turn leads to activation of Renin Angiotensin Aldosterone system. 2. Ventricular dysfunction secondary to sepsis. 3. Administration of an inappropriate fluids. 4. Side effects of drugs. Deficiency of Magnesium per se can cause hypocalcemia, hypokalemia and hypophosphatemia which are related with neuromuscular abnormalities such as hyper excitability and weakness of respiratory muscles. Reduced Magnesium level depletes endogenous antioxidants and recruits inflammatory cells. So hypomagnesemia leads the myocardium to suffer to reperfusion injury. Also by regulating Calcium access into the cell, play a role as native calcium antagonist.

Homeostasis of Magnesium and compensatory mechanisms:

Interaction between kidneys, small bowel and bone maintain Magnesium homeostasis. Acute depletion of Magnesium enhances the tubular reabsorption and absorption from the intestine. This compensatory mechanisms last only for five hours and do not cause any changes in calcium or sodium reabsorption. If Magnesium deprivation continues, bone stores of Magnesium started to contribute for extracellular Magnesium levels. Ionized intracellular Magnesium is an important trigger for this compensatory mechanisms. Henceff, ionized and bound intracellular Magnesium represent buffers whose primary function

seems to be maintaining constancy of the intracellular concentration of free magnesium.

Absorption of magnesium is influenced by 1,25 dihydroxycholecalciferol and in hypomagnesemic state, the absorption may reach upto 70%. Parathyroid hormone increases the magnesium reabsorption from the kidney whereas hypercalcemia and hypermagnesemia inhibit magnesium reabsorption.

Biochemical, Biological and Physiological effects of Magnesium:

Physiological processes that involve storage, transfer and utilization of energy needs magnesium. Signal transducing enzymes like phosphatases and phosphokinases on plasma membranes and intracellular compartments use Mg -ATP complex as substrate. Mg neutralises the negative charge on ATP to facilitate enzyme binding and assists hydrolysis of terminal phosphate bond, thereby facilitating ATP involved enzymatic reactions. Intermediary metabolism is regulated by intracellular Magnesium by activating rate limiting glycolytic and tricarboxylic acid cycle enzymes. Mg2+ (Na+K+) ATPase regulates Sodium transport, Mg2+(HCO3-) ATPase regulates proton transport, and Ca2+ Mg2+ATPase regulates calcium transport. For the generation of cyclic AMP, Mg is required for Adenylate cyclase.

Metabolism of Calcium and Potassium is significantly affected by intracellular Mg. Mg is a divalent cation. So calcium binding sites in the cell

membrane is competed by Mg. By doing this, it modulates calcium release from the sarcoplasmic reticulum and maintain the intracellular resting calcium in a low level. By inhibiting inositol 1,4,5 triphosphate gated calcium channels noncompetitively, it modulates muscle contraction. Also, by acting directly on PTH it controls Calcium balance.

By acting as a cofactor for Na+K+ATPase, it also regulates Potassium transport. Outward movement of Potassium in cardiac cells is blocked by Mg. So in Mg deficiency state, excessive Potassium moves out of cell, in spite of fall in intracellular Potassium levels. So hypomagnesemic state induces depolarization by reducing intracellular Potassium levels. It is known as “inward rectification”. The function of Na+ K+Cl- co transporter also impair in hypomagnesmic state.

Mg inhibits the release of Ach from the presynaptic membrane in neuromuscular junction. By inhibiting calcium, calcium mediated release of Ach is reduced. It also blocks N methyl D aspartate receptors and by this action it also acts as an anticonvulsant. The process of oxidative phosphorylation, metabolism of proteins and transmembrane electrolyte flux in cardiac muscle and neural tissue are potentially affected by low Mg levels.

Pathophysiology:

Magnesium acts as a cofactor for more than 300 enzyme catalysed reactions, most importantly reactions involving ATP. Magnesium has a direct effect on Potassium, Calcium and Sodium channels.

Potassium:

Magnesium inhibits the efflux of potassium channel. So hypomagnesemia leads to hypokalemia by increased excretion of potassium through kidneys. Normally magnesium inhibits the ROMK channels present in the apical tubular membrane. In hypomagnesemic state, the inhibitory effect of magnesium over ROMK channel has lost, results in hypokalemia. So in hypokalemic state, if potassium is persistently low even after correction we should suspect associated hypomagnesemia.

Calcium:

Magnesium inhibits the release of calcium from the sarcoplasmic reticulum. So in low serum magnesium level results in an increased intracellular calcium levels, leads to reduced secretion of parathormone. It leads to hypoparathyroidism and hypocalcemia.

Clinical features of low serum Magnesium level:

Clinical features of hypomagnesemia depends on rapidity of fall in serum Mg level that too ionized form rather than total serum Mg level. On the other hand clinical feature need not be there even when serum total Mg falls less than 0.8mgs/dl.

Effects of hypomagnesemia on neuromuscular apparatus in relationship with hypocalcemia:

Hypomagnesemia results in irritability of neuromuscular system manifested in the form of appearance of Chvostek sign, trousseau's sign, fasciculation, tremors& tetany.

So it results in various neurlogical manifestations such as involuntary movements(athetoid), apathy, convulsions, nystagmus, delirium and coma. And also associated weakness in relation to low serum Mg level results in delayed weaning from ventilators. So it is important to assess serum Mg level and prompt correction of hypomagnesemia in ventilated patients to avoid delay in weaning.

Neuromuscular manifestations of hypomagnesemia are also attributed to associated hypocalcemia. However, studies showed that tetany can occur due to hypomagnesemia alone in the setting of normal serum Mg level.

Anyway neuromuscular manifestations may be due to combined effects of ionized hypomagnesemia as well as hypocalcemia. In the setting of hypomagnesemia, supplementation of calcium alone will not correct hypocalcemia unless the administration of Mg.

The effect of magnesium in neurological system may be due to

1. Reduction in electrical excitation
2. Blocking the release of acetylcholine
3. Blocking N-methyl D-aspartate (NMDA) glutamate receptors, an excitatory neurotransmitter of the CNS.

Arrhythmias:

Adequate function of the Na K ATPase, which is present in cardiac myocytes, depends on normal serum magnesium levels. So hypomagnesemia inhibits the reuptake of potassium, results in intracellular potassium depletion, which results in tachycardia.

Pre- eclampsia:

Magnesium has an indirect antithrombotic effect over platelets and endothelial function. It increases the levels of prostaglandins, decreases the level of thromboxane and angiotensin II, microvascular leakage and

constriction of blood vessels through its functions similar to calcium channel blockers. So cerebral vasospasm may lead to convulsions.

Asthma:

Magnesium has a bronchodilatory effect. So its deficiency leads to bronchial asthma.

Other symptoms:

Excessive tiredness, generalized weakness, muscle cramps, cardiac arrhythmias. Other neurological symptoms that may be associated with hypomagnesemia are involuntary movements like athetosis and jerking, nystagmus and Babinski reflex, pshychological problems like hallucinations and depression, hypertension.

Magnesium by causing relaxation of bronchial smooth muscles, it causes bronchodilatation

Causes of hypomagnesemia:

Hypomagnesemia may be due to the diet containing an inadequate magnesium, reduced absorption of magnesium from the intestine, or excessive excretion through kidneys. The following conditions may also be associated with low serum magnesium levels. They are

Drugs:

1. Both loop and thiazide diuretics use (the most common cause)

2. Antibiotics (aminoglycoside, gentamicin, pentamidine, amphotericin and tobramycin) which block resorption of magnesium from the loop of Henle. The incidence of hypomagnesemia is 30% among the patients using above said antibiotics.

3. Proton pump inhibitors like omeprazole in long term use can cause hypomagnesemia.

4. Digitalis and Adrenergics by displacing magnesium inside the cell can cause hypomagnesemia.

5. Cisplatin and Ciclosporin cause hypomagnesemia by the stimulation of excretion of Mg through kidneys.

Genetic causes:

Genetic mutations involving SLC12A3, CLNCKB, BSND, KCNJ10, FXYD2, HNF1B or PCBD1 cause Gitelman like disease. In these, hypomagnesemia often accompanied by other electrolyte abnormalities like hypocalciuria and hypokalemia. Above said genes are encoding proteins involved in reabsorption of electrolytes from the distal convoluted tubules of kidney.

Mutations in CLDN19, CLDN16, CLCNKB or CASR cause hypercalciuric hypomagnesemic syndromes. Reabsorption of divalent cations from the thick ascending limb of Loop of Henle of the Kidney is impaired. This causes hypercalciuria and hypermagnesiuria.

Mitochondropathies such as Kearns-Sayre syndrome characterised by mutations in SARS2, MT-TI also associated with hypomagnesemia.

Other genetic causes include mutations in TRPM6, CNNM2, EGF,KCNA1, FAM111A or EGFR also associated with hypomagnesemia. Proteins encoded by above said genes cause transcellular absorption of Mg from the distal convoluted tubule.

Metabolic abnormalities:

Insufficiency of Selenium, Vitamin B6, Vitamin D associated with hypomagnesemia.

Gastrointestinal causes: High levels of Mg is secreted through the distal digestive tract. So hypomagnesemia can be caused by secretory diarrhea. Therefore conditions like inflammatory bowel disease, celiac sprue and Whipple’s disease can cause hypomagnesemia.

Renal transplant, recovery phase of acute tubular necrosis, postobstructive diuresis.

Diabetes mellitus: By causing glycosuria or ketoaciduria, DM associated with hypomagnesemia in 38% of diabetic patients.

Hypercalcemia

Depletion of phosphate

Excessive lactation and 3rd trimester of pregnancy

Endocrine causes:

Hyperthyroidism, hyperparathyroidism, diabetes mellitus and hyperaldosteronism.

Nutritional:

Prolonged TPN without Mg supplementation

Starvation associated metabolic acidosis

Protein calorie malnutrition

Kwashiorkor

Chronic alcoholism

Others:

Acute myocardial infarction: within 2 days of heart attack, 80% of patients associated with hypomagnesemia. Increased catecholamines may cause an intracellular shift of magnesium.

Acute pancreatitis, Malabsorption

Fluoride poisoning

Massive blood transfusions

Osteolytic lesions of the bone, active phase of Paget's disease of bone

Cause for hypermagnesemia:

Renal failure

Use of magnesium containing antacids or enema

Laxative abuse

Parenteral nutrition

Treatment with magnesium for eclampsia patients

Intoxication with lithium

Hypothyroid state

Dehydration associated with diabetic ketoacidosis

Addison's disease and post adrenelectomy state

Accidental consumption of large amount of sea water

Work up of hypomagnesemia:

Since it is easy to measure the serum magnesium levels, it becomes the method of choice for estimating magnesium content. But its use in evaluating total body stores is limited. There are other methods to estimate the magnesium content. These are as follows:

- Red cell content
- Content of myocyte in skeletal muscle
- Content of mononuclear cells
- 24 hours of urinary excretion
- Fractional excretion of magnesium
- By using fluorescent dye or nuclear magnetic resonance spectroscopy, the measurement of intracellular free magnesium ion concentration

When measuring serum magnesium to assess the magnesium deficiency, two caveats should be considered. First, eventhough free magnesium is biologicall active, most methods used for assessing serum magnesium content measure only total magnesium concentration. Since 30% of magnesium is bound to albumin and exist in an inactive form, spuriously low magnesium values can occur in hypoalbuminemic state.

The second caveat is that an intracellular magnesium plays a major physiological role at an intracellular level. Apart from magnesium content of bone, which is poorly mobilised, the ECF space contains only 2% of total body magnesium therefore it may not always reflect the intracellular magnesium level. Unfortunately for measuring the intracellular magnesium, there is no simple, quick and accurate test is available.

The measurement of magnesium retention after acute magnesium loading is useful to assess direct intracellular magnesium. When there is a strong clinical suspicion of magnesium deficiency for example presence of unexplained neuromuscular and cardiovascular abnormalities in the presence of normal magnesium levels, we can use the above said testing.

Interpretation:

After a loading dose of magnesium (2.4mg/kg of lean body weight) which should be infused over 4 hours, if the patient excretes <80% over 24 hours of an infused magnesium then the patient is in hypomagnesemic state.

Measurement of protein has a role in assessing the hypomagnesemia because the majority of extracellular potassium is protein bound.

Since the magnesium deficiency contributes in the occurrence of hypocalcemia, hypokalemia and hypophosphatemia, measurement of serum

calcium, potassium and phosphate is important in work up of hypomagnesemia.

Electrocardiography and cardiac monitor: Hypomagnesemia has nonspecific findings in ECG. They include depression of ST segment, tall peaked T waves, low voltage complexes, prolongation of PR interval and widening of QRS complexes.

Excretion analysis:

If history wise there is no apparent cause for hypomagnesemia, then 24 hours of urinary magnesium excretion or fractional excretion of magnesium in a random urine specimen can be useful to distinguish between gastrointestinal or renal losses.

The formula for fractional excretion of magnesium:

$$[(UMg * PCr) / PMg*UCr*0.7)] * 100$$

Since only about 70% of circulating Mg is in free form, the plasma Mg concentration should be multiplied by 0.7.Because the glomeruli filtered only the unbound form of magnesium. In a hypomagnesemic state, the kidneys will try to preserve the serum magnesium as much as possible. So magnesium excretion is very low. Thus daily magnesium excretion of more than 2mEq in 24 hours or fractional excretion of Mg >3% in persons with normal kidney function suggest renal wasting of magnesium.

Sample requirements for the measurement of magnesium:

Either serum or heparinised plasma can be used to measure serum magnesium levels.

Measurement of urinary magnesium can be helpful to find out the renal loss as the cause for hypomagnesemia. To prevent precipitation of magnesium complexes, urinary samples has to be collected in the container which contains acid as the preservative. For the measurement of free magnesium, we can use whole blood sample in addition to heparinised plasma and serum.

Precautions taken during the measurement of magnesium:

Zinc containing heparin preparations should be avoided, because they increase measured plasma magnesium. Similarly anticoagulants which contain oxalate, citrate and EDTA should also be avoided, because these preparations form magnesium complexes. As erythrocytes contain large amount of intracellular magnesium, hemolysed samples should be avoided because it gives false positive results for hypermagnesemia .Either serum or plasma should be separated from the whole blood as soon as possible, because the leakage of magnesium from RBCs gives spurious hypermagnesemia**.**

Analytical considerations:

Analytical methods

1. Photometric: numerous metallochromic indicators such as calmagite, xylidyl blue or magon, chlorophosphonazo III and arsenazol are used to measure the magnesium. When binding with magnesium at alkaline pH they give various colours depends on magnesium levels. Ethylene glycol acetic acid which acts as calcium chelating agent is added to reduce interference by calcium.

2. Formazon dye which forms complex with serum magnesium at alkaline pH. Thin film reflectance photometry has been used to measure this dye complex.

3. Atomic absorption spectrometry: to reduce the interference by anions as well as to reduce the viscocity, the samples are diluted with lanthanum-hydrochloride solutions. The diluted samples are aspirated into an air acetylene film. The ground state magnesium ions absorb light from a magnesium hollow cathode lamp. The number of ground state magnesium ions in the flame is directly proportional to the absorption of light which is measured at 282.5nm.

4. Free magnesium by ion selective electrode(ISE): Calcium ions will interfere with magnesium ISE. To overcome this effect, both ions should be measured simultaneously. So simultaneously free calcium is

determined and the results are used to correct the results for magnesium according to the known selectivity of the magnesium electrode.

Atomic absorption spectrometry is used as a reference method.

By using thin film reflectance photometry, elevated calcium may cause small overestimation in magnesium.

The binding ability of magnesium with albumin increases with pH. So when measuring free magnesium levels, the pH should also be measured and it should be adjusted to pH 7.4.

Clinical uses of measurement:

Indications:

1. Clinical suspicion of hypomagnesemia in the following settings:

    Refeeding

    During the treatment of diabetic ketoacidosis

    Patients who are on long term IVF replacement

    Chronic diarrhea

    Malabsorption syndrome

    Patients on renal replacement therapy

    Post renal transplant recipients

On long term treatment with diuretics

Chronic alcoholic

Endocrine abnormalities such as hyperparathyroidism, hyperaldosteronism, thyrotoxicosis.

2. Suspected hypermagnesemic state:

Renal failure

Tumour lysis syndrome

On magnesium replacement therapy.

3. In the setting of low serum total magnesium and low serum albumin, it is advisable to measure the free magnesium levels, as it may be normal.

Treatment and management of hypomagnesemia :

By inhibiting the bioactivity of parathyroid hormone, hypomagnesemia often leads to hypocalcemia. So without correcting the magnesium deficiency, hypocalcemia won't get corrected.

1.Diet: green vegetables such as spinach which have chlorophyll molecules are the rich source for magnesium. Some legumes (beans and peas), seeds and nuts, whole unrefined grains are also rich sources of magnesium.

2. Pharmacologic therapy: depends upon the severity of clinical manifestations, the route of magnesium repletion will be decided. For example

if the hypomagnesemic-hypocalcemic patients presented with tetany or ventricular arrhythmias, the. magnesium correction should be given parenterally (50 mEq of I.V magnesium slowly over 8-24 hours). The above said dose can be repeated till the plasma magnesium levels of 1mg/dl.

In the regulation of Magnesium reabsorption which takes place predominantly in the loop of Henle, the plasma concentration of magnesium play a major role. So during the correction of hypomagnesemia, an abrupt elevation of serum magnesium levels reduces the reabsorption from the loop of Henle. So 50% of infused magnesium gets excreted through kidneys.

Since the equilibration of magnesium between the serum and the intracellular spaces and tissues takes place very slowly. So measurement of serum magnesium levels immediately after the administration of magnesium will give spuriously high serum magnesium values.

For the above said reasons, oral supplementation of magnesium should be given in an asymptomatic patients. In the absence of intestinal malabsorption, 33% will be the bioavailability for oral preparations. Different p reparations are available for oral supplementation for example, Mag-Ox 400 contains Magnesium oxide; slow-Mag contains Magnesium chloride; Mag-Tab contains Magnesium lactate. The above said preparations contain 5-7mEq of magnesium per tablet. For severe hypomagnesemia six to eight tablets should

be taken in divided doses. For mild and asymptomatic patients two to four tablets are enough.

In the presence of associated hypokalemia and hypomagnesemia, parallel correction of calcium and potassium should be done, because the correction of magnesium alone take several days to correct hypocalcemic and hypokalemic state. With associated hypocalcemia, if we have not supplemented the calcium during the administration of magnesium sulphate, tetany can occur. Because acute drop of ionized calcium levels can occur due to formation of calcium-sulfate complexes and their increased excretion through kidneys.

Sulfate ions by generating more negative trans epithelial potential differences in renal tubular epithelial cells, enhances the excretion of potassium and worsens the hypokalemic state. Monitoring of acute hypermagnesemia (areflexia and respiratory depression) is important in patients undergoing magnesium correction. Patients in whom there is an evidence of renal dysfunction, they are more prone for acute hypermagnesemia during Mg correction. If plasma creatinine levels >than 2mg/dl, we should infuse only 25-50% of the normal dose required.

If there is an evidence of hypermagneseia, 1-2 ampules of calcium chloride or gluconate which acts as antidote for hypermagnesemia, should be infused immediately.

Diuretic induced hypomagnesemia:

Patients who are on diuretic therapy, if develop hypomagnesemia, adding of potassium sparing diuretic or changing from plain thiazide type diuretic to thiazide/potassium sparing diuretic combination will be useful.

Those patients should consume magnesium rich diet, like meat, green vegetables, nuts, cereals, sea foods and diary products. They should be periodically monitored for the development of hypomagnesemia. In spite of changing diuretics, if hypomagnesemia persists, they should be supplemented with an oral tablets.(sustained release)**.**

Important facts about magnesium:

Magnesium deficiency in general population can lead to high incidence of sudden coronary deaths, stroke, diabetes and cancer.

Deficiency of magnesium is often misdiagnosed because only one percent of the total body magnesium is stored in the blood.

Even a mild deficiency of magnesium can cause irritability, mental depression, confusion, nervousness, increased sensitivity to noise, twitching, trembling, insomnia and apprehension.

The modern diet which consists of refined grains, processed foods and sugar is very poor source for magnesium.

Transdermal magnesium chloride is the most effective way to improve serum magnesium levels quickly.

Magnesium deficiency is associated with every known illness &it is the critical mineral required for electrical stabilisation of each cell in our body.

Hypomagnesemia causes metabolic functions to decrease which leads to further stress on the body. Ultimately the body's ability to absorb and retain the magnesium is reduced.

If patients with marginal deficiency of magnesium suffered with any stressful event , it will trigger additional magnesium loss. In extreme situations sudden drop in serum magnesium may lead to cardiac arrest.

Magnesium is considered as an anti-stressed mineral. It acts as a natural tranquilizer by causing relaxation of both skeletal as well as smooth muscles of blood vessels and GI tract.

Thirst means not only lack of water, it means that the person is not getting enough electrolytes and nutrients. The initial symptoms of magnesium deficiency may be subtle, because most of the magnesium is stored in the tissues. Leg cramps, twitching of muscle fiber and foot pain.

RESULTS

There was significantly increased rate of death in hypomagnesemic patients 59% compared to normal magnesium patients.

11(21%)patients had delayed recovery in hypomagnesemic patients compared to normal magnesium patients9(19%).

Rate of recovery patients was higher in normal magnesium patients 20(42%) than hypomagnesemia patients 2(4%)

Hypomagnesemic patients had statistically significant difference in PCV values ($p<0.0105$) when compared to normomagnesemic patients.

Hypomagnesemia patients had higher acute physiological scoring, chronic health point and total score.

Hypomagnesemic patients had significant hyponatremia. No stastically significant difference between both groups with respect to potassium and serum creatinine..

Hypomagnesemic patients had significantly lower temperature than normal magnesium patients.

DEMOGRAPHY

1.AGE (student t test)

AGE	mean±SD	Pvalue
Normal magnesium	47.5±14.667	0.0917
hypomagnesimia	52.596±15.2	

The two-tailed P value equals 0.0917. By conventional criteria, this difference is considered to be not quite statistically significant.

Confidence interval:

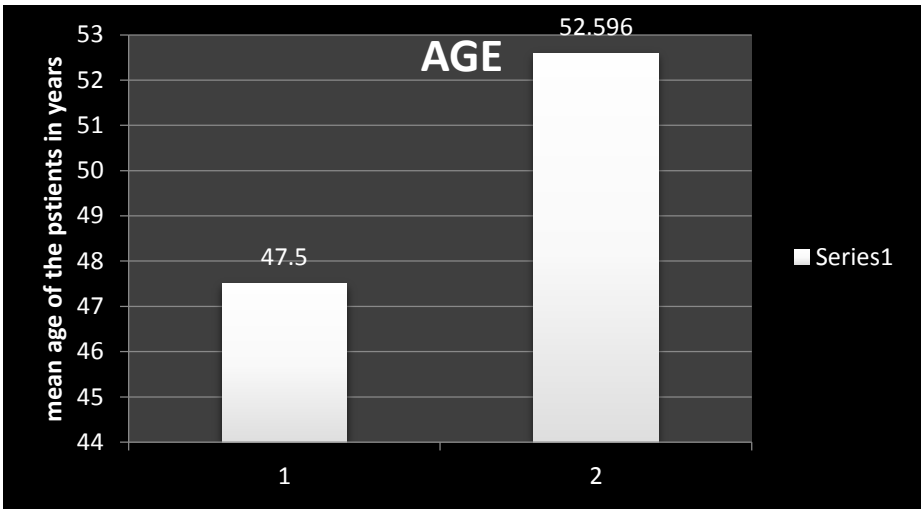
The mean of normal magnesium minus hypomagnesimia equals -5.09600 95% confidence interval of this difference: From -11.03302 to 0.84102

Intermediate values used in calculations:

t = 1.7034

df = 98

standard error of difference = 2.992



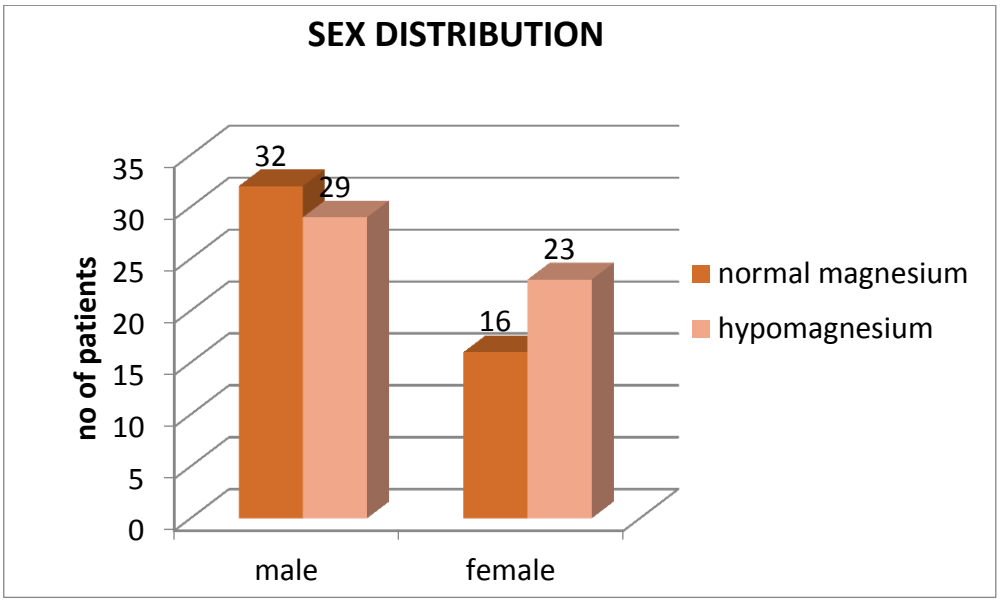
2.SEX(chi square test)

	Males	**Females**	**P value**
Normal magnesium	32	16	0.3623
hypomagnesimia	29	23	

Chi-square with Yates correction

Chi squared equals 0.830 with 1 degrees of freedom. The two-tailed P value equals 0.3623.

The association between rows (groups) and columns (outcomes) is considered to be not statistically significant.



VITAL STATISTICS(student t test)

VITALS	Normal magnesium		P value
TEMPERATURE	38.50±1.300	37.9±1.27	**0.0217**
HEART RATE	131.9±33.77	128.34±36.26	0.6134
MAP	81.58±30.8	85.2±36	0.5917
RESPIRATORY RATE	37.45±20.78	31.48±7.86	0.0567

Both groups were comparable with respect to heart rate, MAP and respiratory rate. Hypomagnesemic patients had significantly lower temperature than normal magnesium patients.

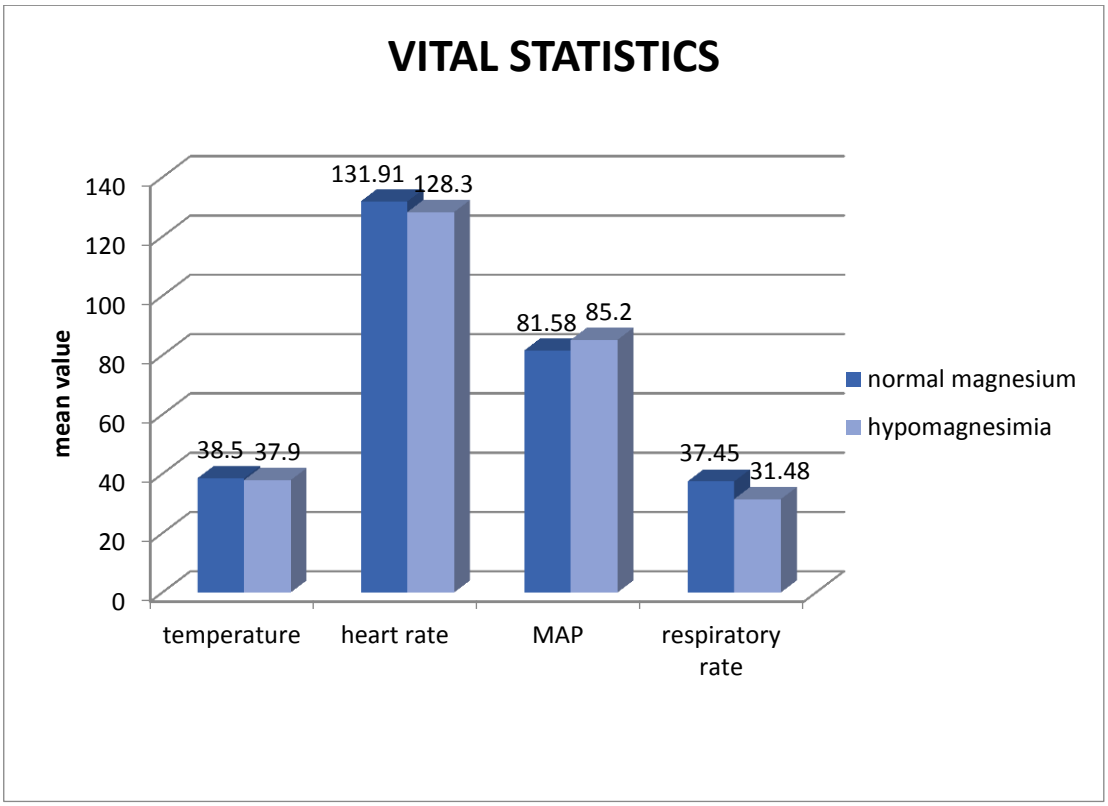
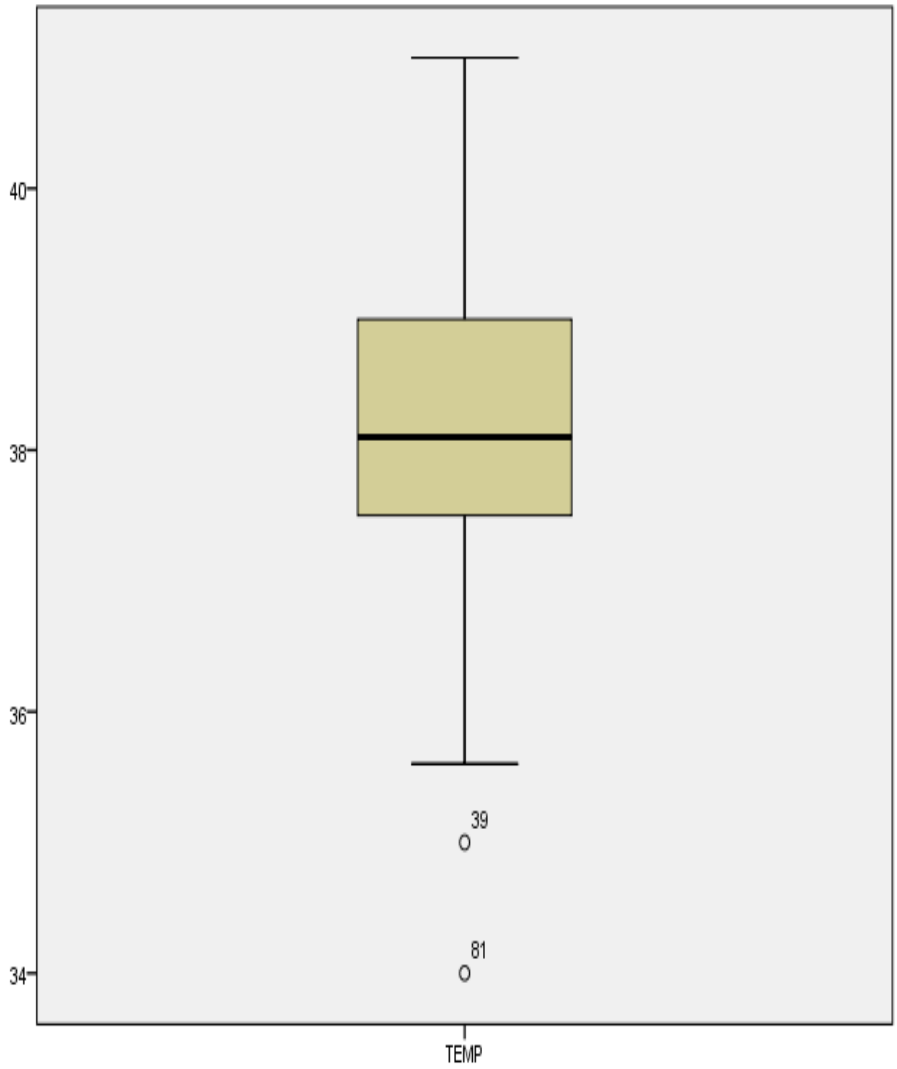
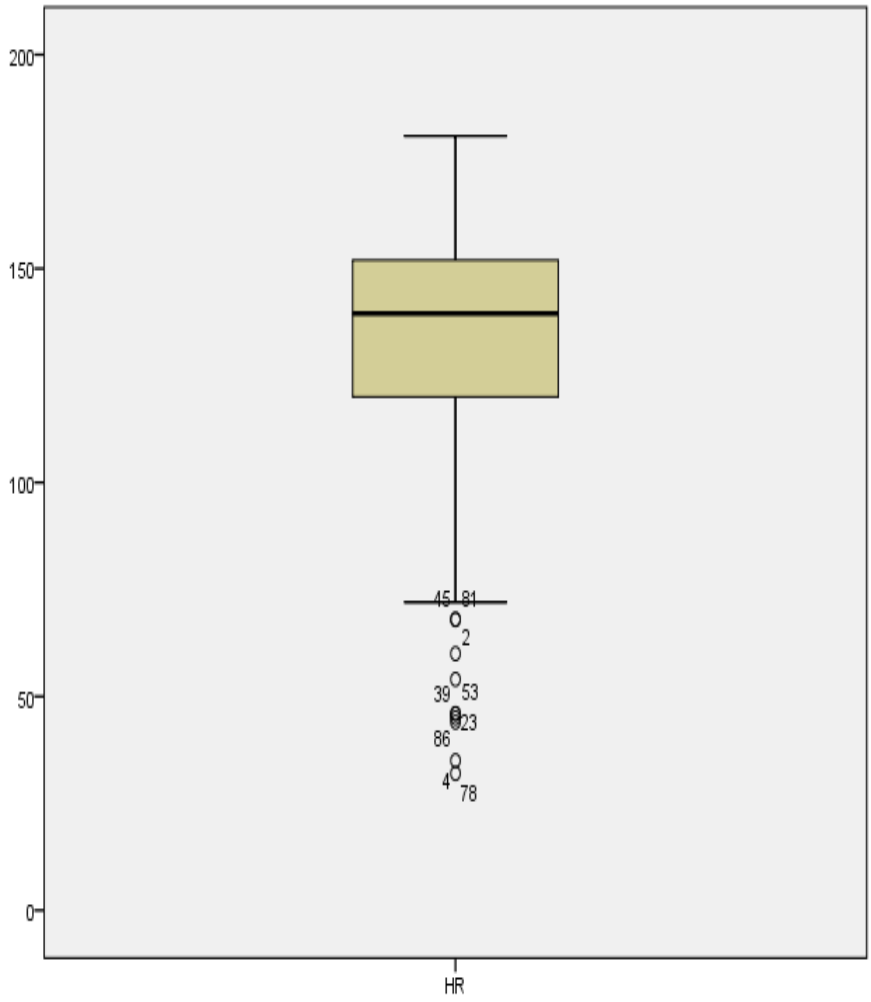

VITAL STATISTICS
mean value
140
120
100
80
60
40
20
0
131.91
128.3
81.58
85.2
38.5
37.9
37.45
31.48
temperature
heart rate
MAP
respiratory rate
normal magnesium
hypomagnesimia

Figure : Box – Whisker Plot of Temp.



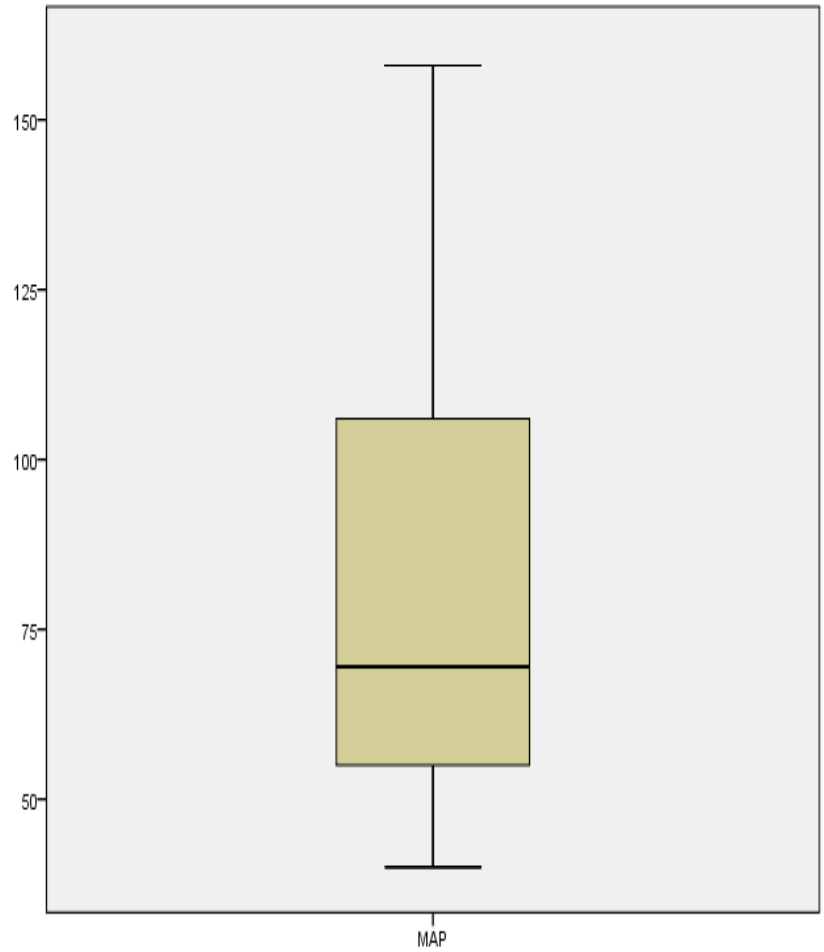
The temperature varies from maximum of 41 degree C to minimum of 34 degree C among the entire study group.

Figure : Box – Whisker Plot of HR.



The heart rate varies from minimum of 32/min to maximum of 181/min among the entire study group.

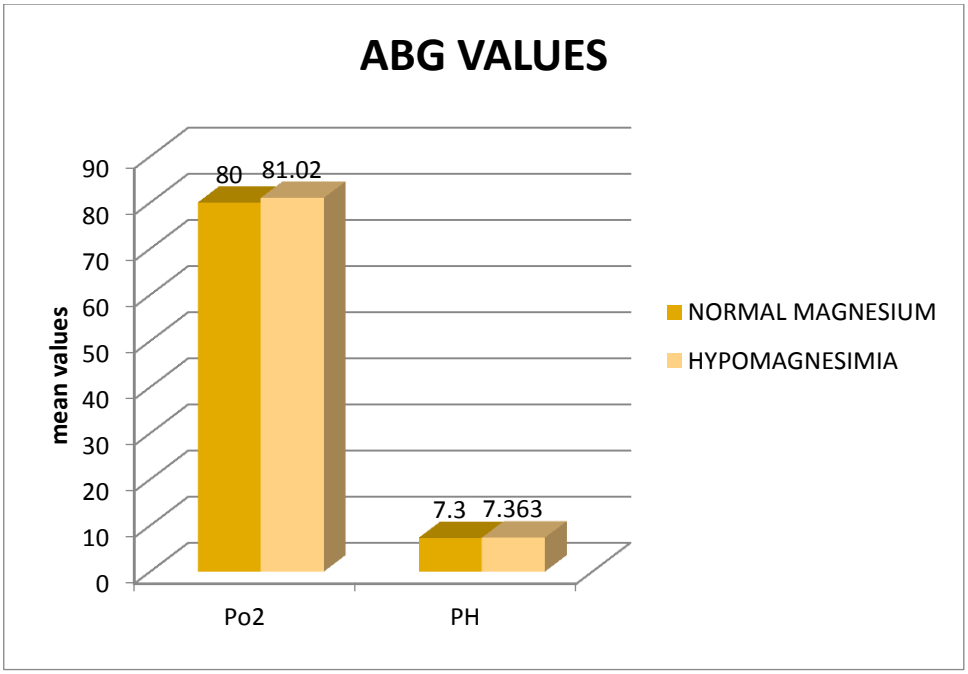
Figure: Box – Whisker Plot of MAP.



MAP varies from minimum of 40mmHg to maximum of 158 mmHg among the entire study group.

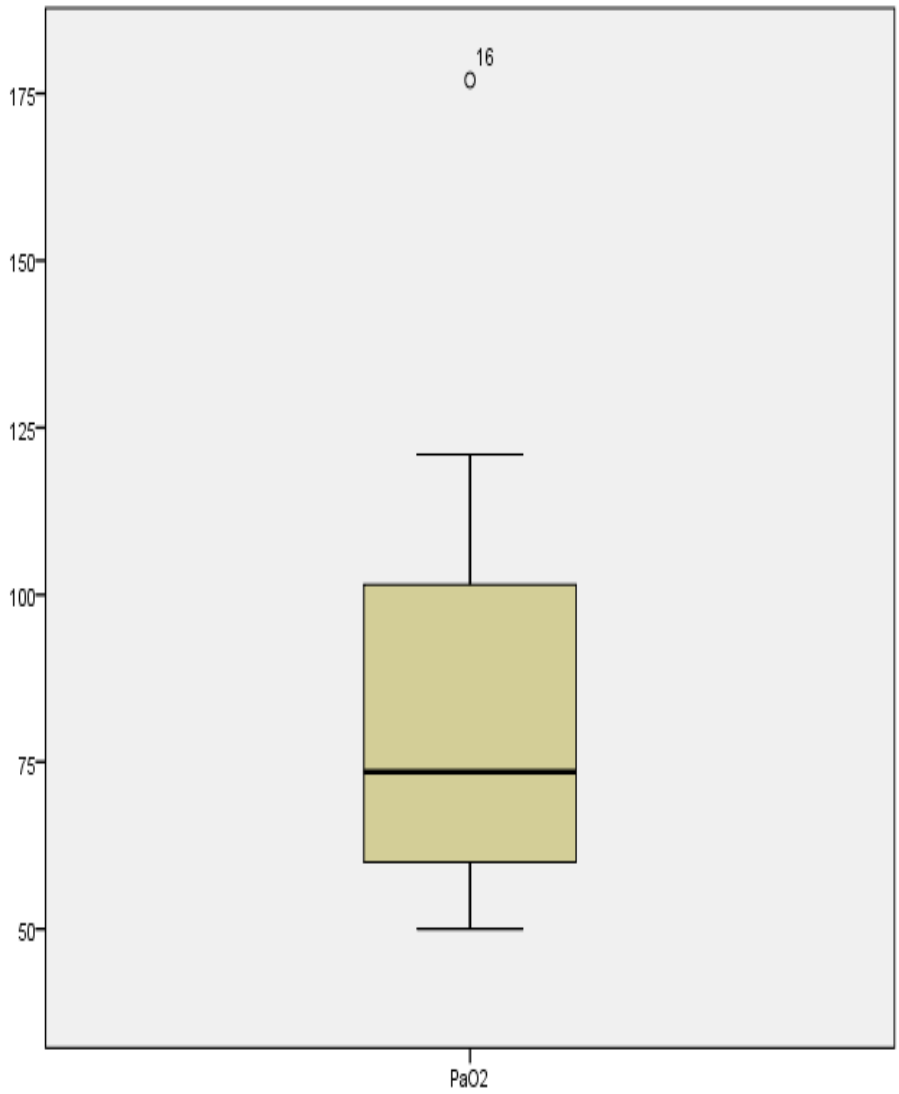
ABG VALUES(STUDENT T TEST)

	Normal magnesium	**Hypomagnesemia**	**P values**
Po2	80±25.348	81.02±21.06	0.8267
Ph	7.3 ±0.46	7.363±0.07	0.3315



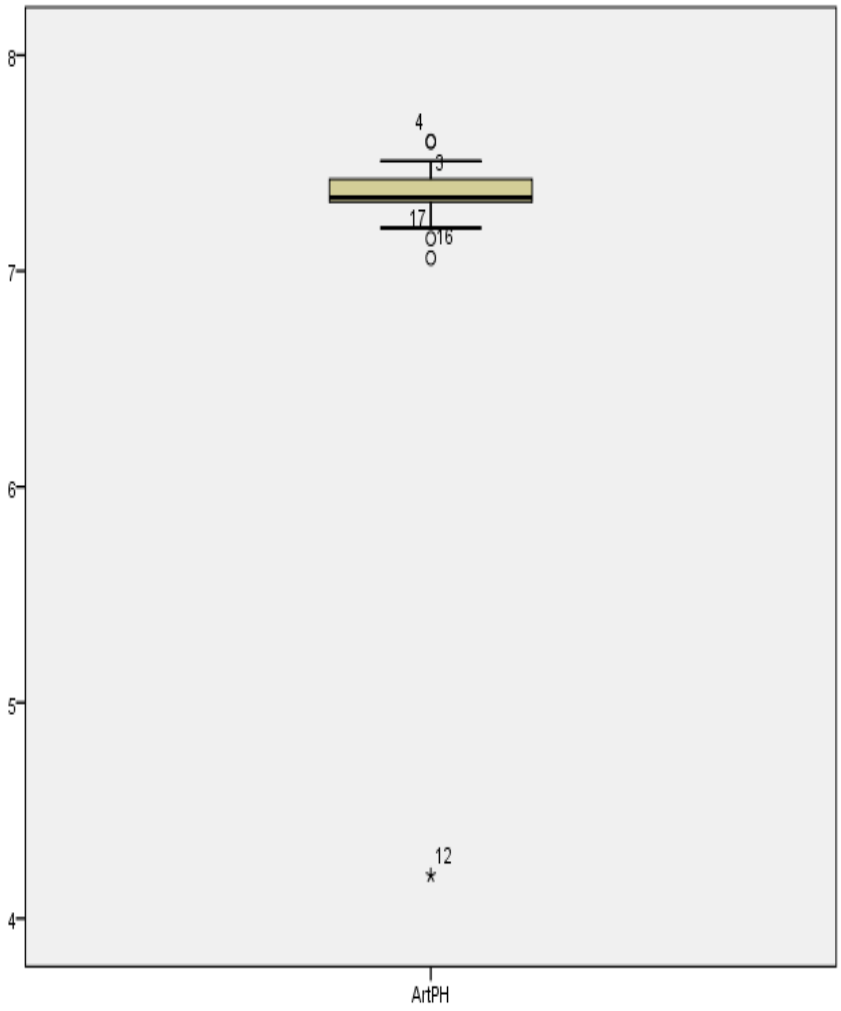
There was no statistically significant difference between the two groups with respect to PH and PO2

Figure: Box – Whisker Plot of PaO2.



PaO2 varies from maximum of 177mmHg to minimum of 50 mmHg among the entire study group.

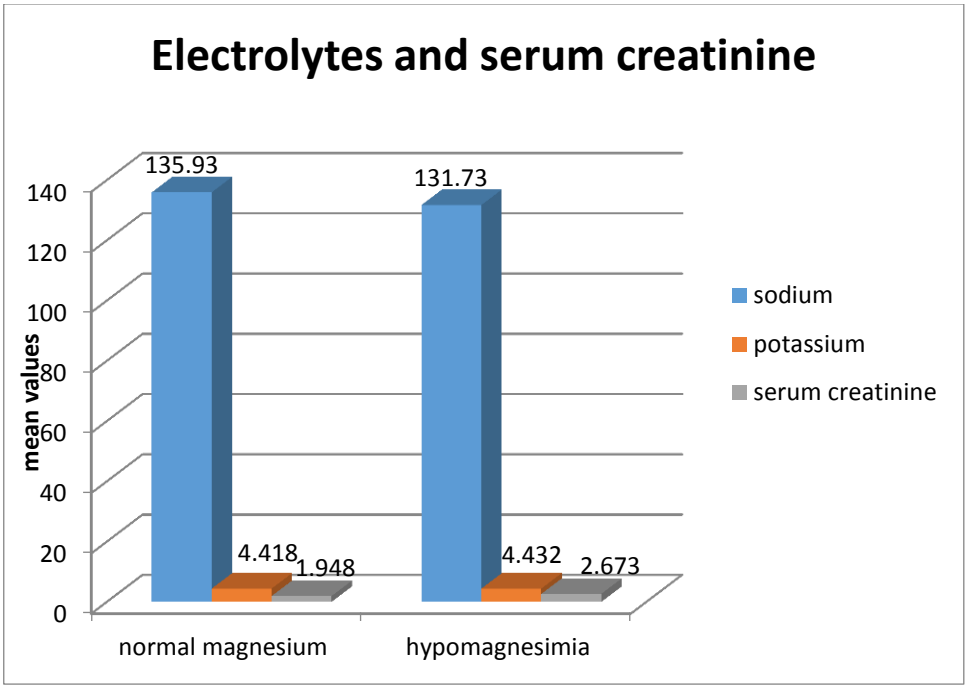
Figure: Box – Whisker Plot of ArtPH.



Arterial pH varies from maximum of 7.60 to minimum of 7.21 among the entire study group.

SERUM ELECTROLYTES AND CREATININE(student t test)

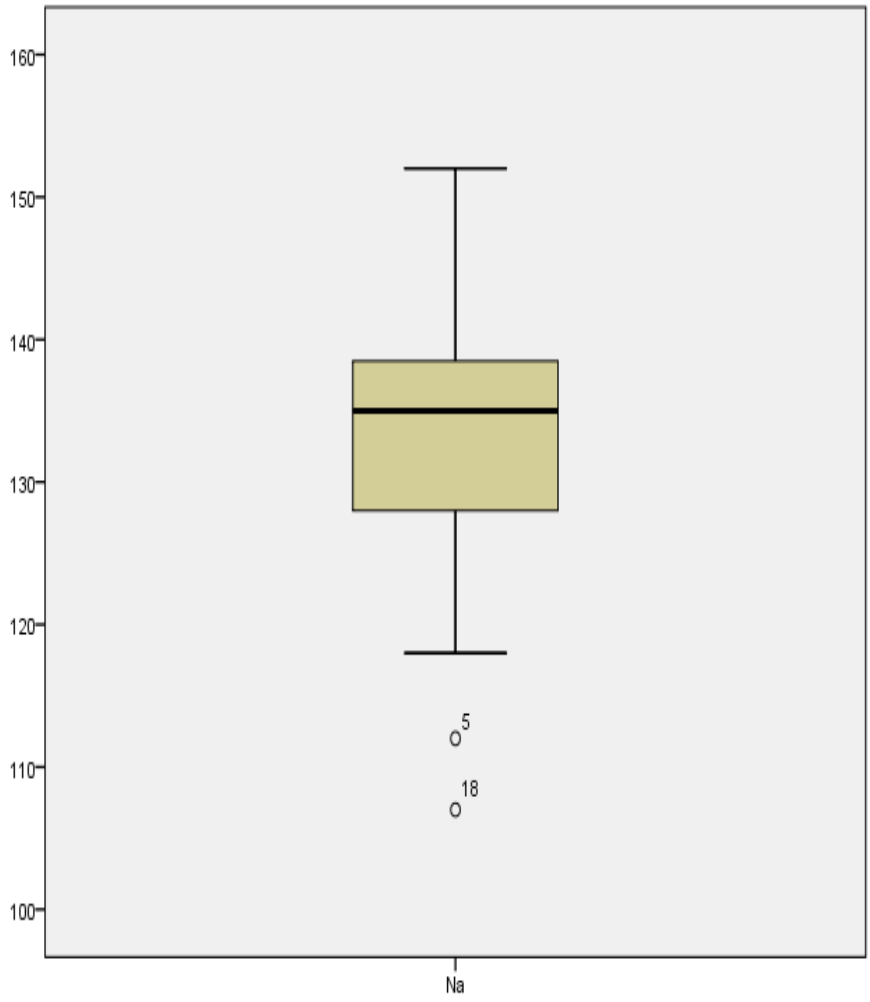
	Normal magnesium	hypomagnesemia	P values
Serum sodium	135.93±7.864	131.73±9.378	**0.0175**
Serum potassium	4.418±0.63	4.432±0.864	0.9269
Serum creatinine	1.948±2.15	2.673±1.98	0.0823



Both groups were compared with respect to serum electrolytes and serum creatinine.

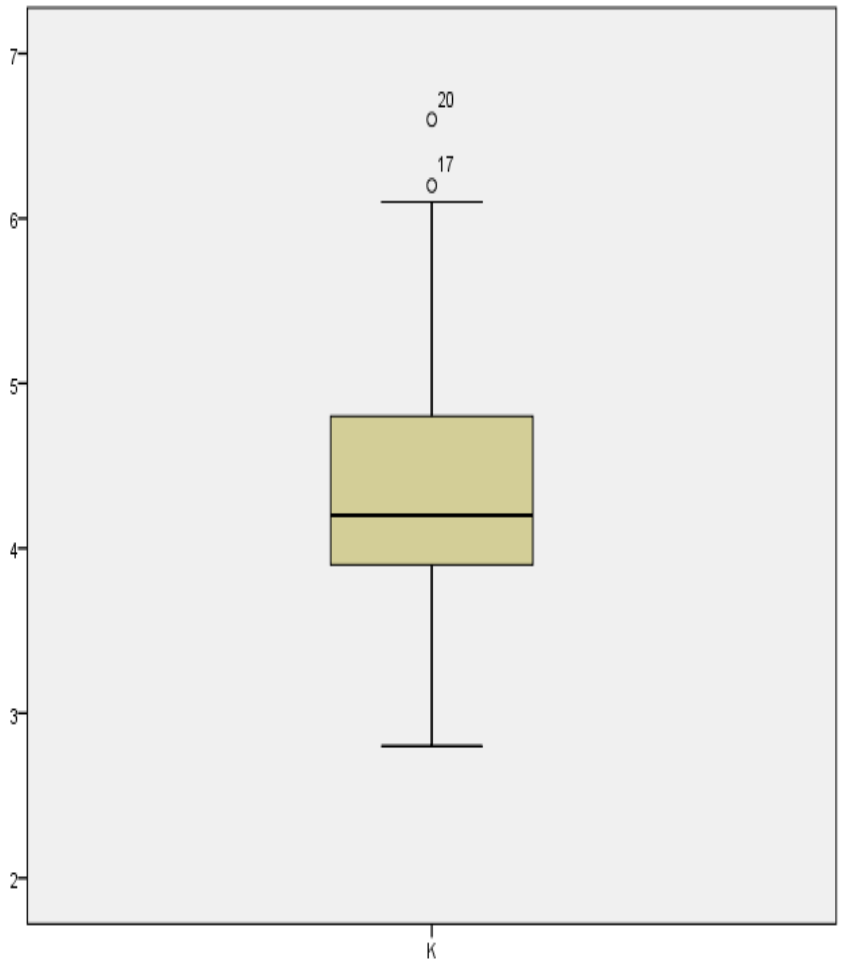
Hypomagnesemic patients had significant hyponatremia. No statically significant difference between both groups with respect to potassium and serum creatinine.

Figure: Box – Whisker Plot of Na.



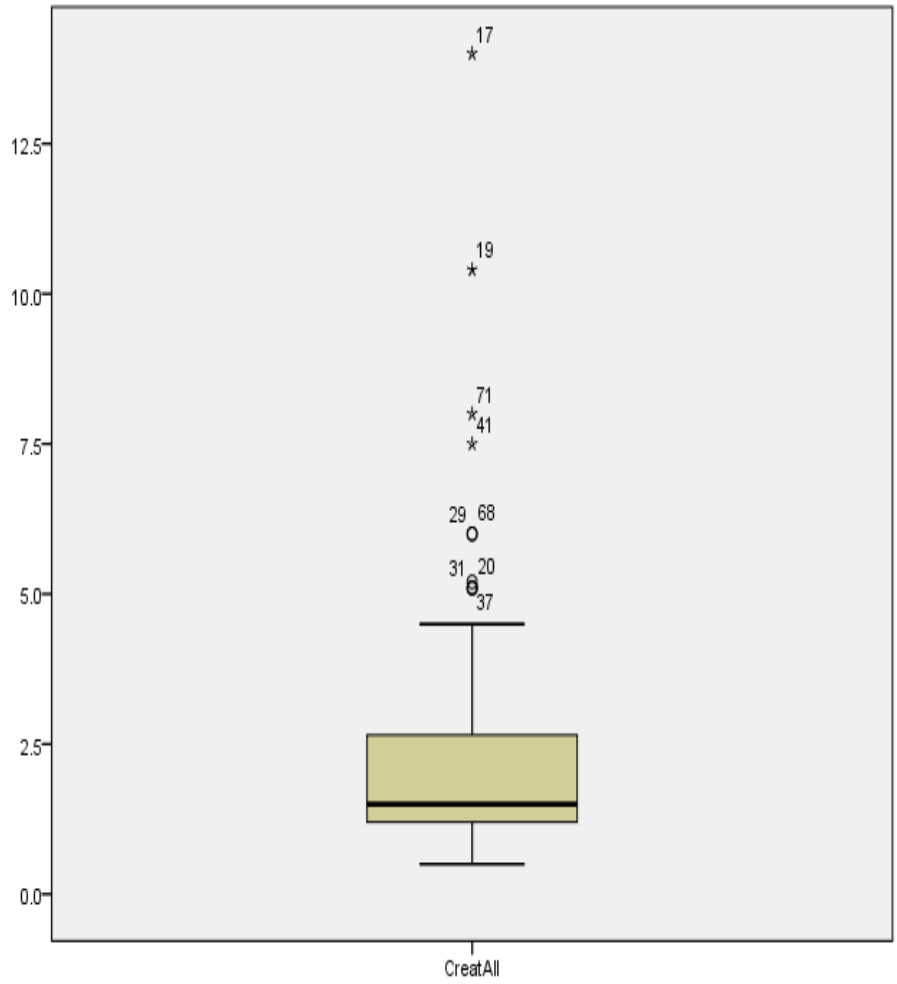
Serum sodium varies from the maximum of values of 152mEq/L to minimum of 107 mEq/L among entire study group. Also there is statistically significant difference in serum sodium between normomagnesemic and hypomagnesemic patients.

Figure: Box – Whisker Plot of K.



Serum potassium varies from the minimum values of 2.8 to maximum values of 6.6 mEq/ L in entire study population.

Figure: Box – Whisker Plot of Creatinine.



Serum creatinine varies from maximum values of 8.2mg/dl to minimum of 0.8mg/dl in the entire study population.

SCORING(student t test)

	Normal magnesium	hypomagnesimia	P values
PCV	30.156±7.28	26.30±7.487	**0.0105**
TC	19187.5±10266.2	16314±10115.36	0.1620
APS	20.38±3.656	22.423±4.6023	**0.0163**
GCS	4.33±4.08	4.627±3.26	0.7145
CHP	5	5	
TOTAL	21.31±3.14	25.44±3.516	**0.0001**

Hypomagnesemic patients had statistically significant difference in PCV values ($p<0.0105$) when compared to normomagnesemic patients.

Hypomagnesemia patients had higher acute physiological scoring, chronic health point and total score.

1.APS:

P value and statistical significance:

The two-tailed P value equals 0.0163

By conventional criteria, this difference is considered to be statistically significant.

Confidence interval:

The mean of Group One minus Group Two equals -2.043000
95% confidence interval of this difference: From -3.701482 to -0.384518

Intermediate values used in calculations:

t = 2.4446

df = 98

standard error of difference = 0.836

2. TOTAL SCORE:

P value and statistical significance:

The two-tailed P value is less than 0.0001

By conventional criteria, this difference is considered to be extremely statistically significant.

Confidence interval:

The mean of Group One minus Group Two equals -4.13000
95% confidence interval of this difference: From -5.45707 to -2.80293

Intermediate values used in calculations:

t = 6.1759

df = 98

standard error of difference = 0.669

3. GCS

P value and statistical significance:

The two-tailed P value equals 0.7145

By conventional criteria, this difference is considered to be not statistically significant.

Confidence interval:

The mean of Group One minus Group Two equals -0.2700
95% confidence interval of this difference: From -1.7302 to 1.1902

Intermediate values used in calculations:

t = 0.3669

df = 98

standard error of difference = 0.736

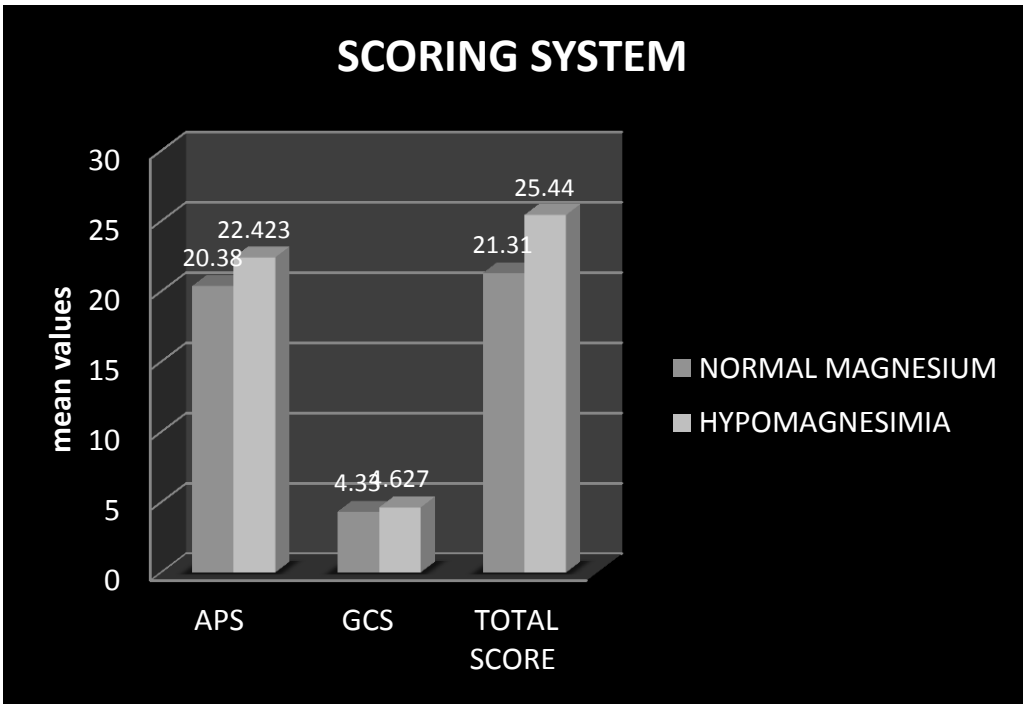
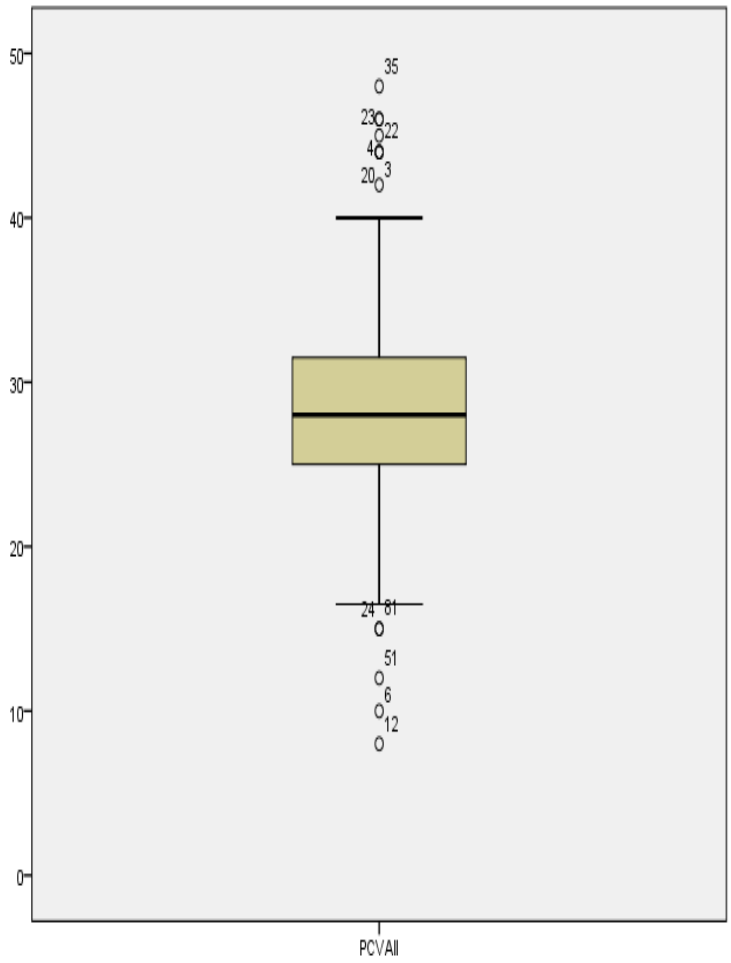
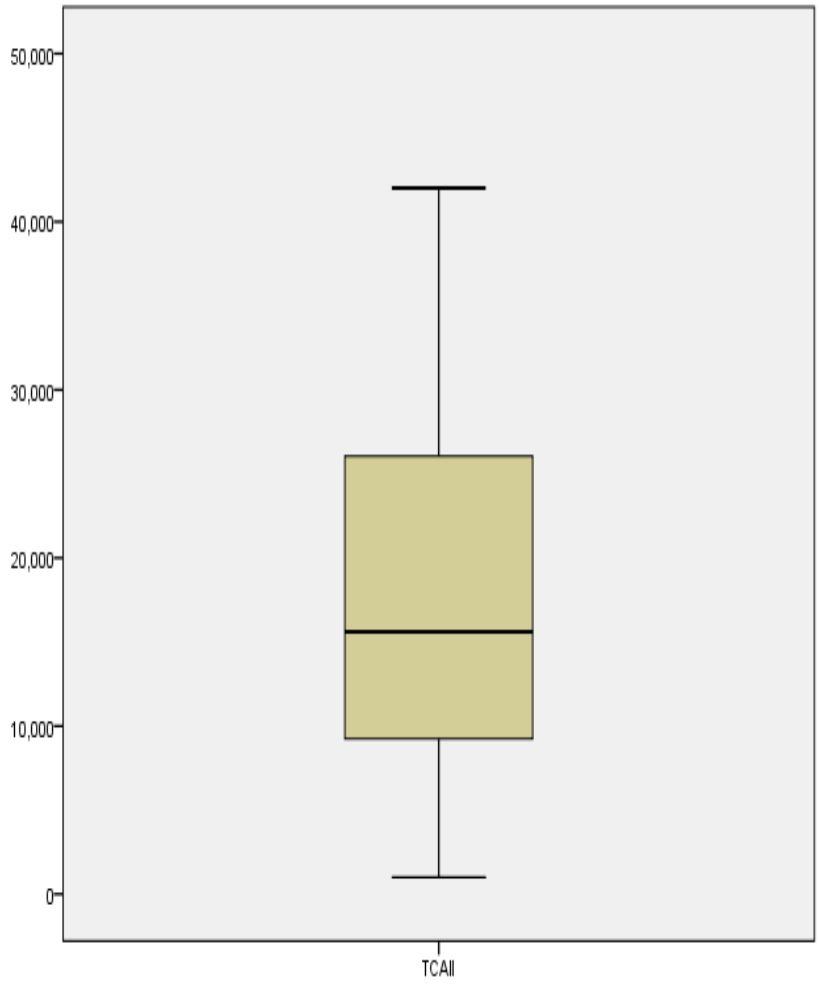

SCORING SYSTEM
mean values
30
25
20
15
10
5
0
20.38
22.423
4.33
4.627
21.31
25.44
APS
GCS
TOTAL SCORE
NORMAL MAGNESIUM
HYPOMAGNESIMIA

Figure: Box – Whisker Plot of PCV.



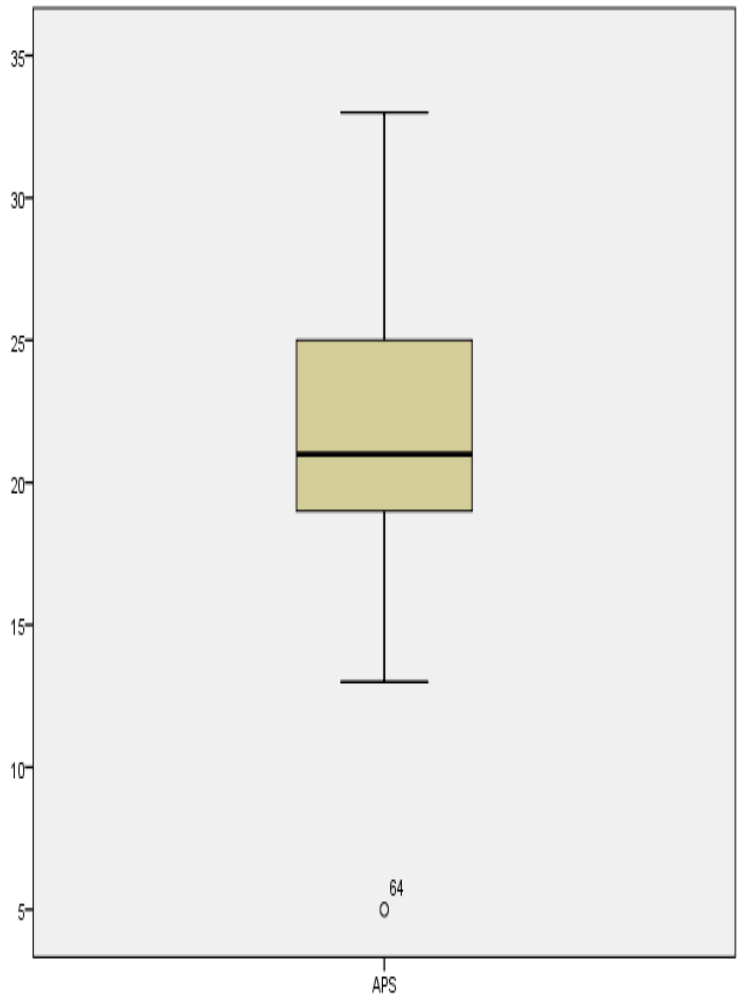
Packed cell volume among the entire study group varies from the minimum 8 to maximum of 48. Also there is statistical significance of PCV between normomagnesemic and hypomagnesemic patients.

Figure: Box – Whisker Plot of TC.



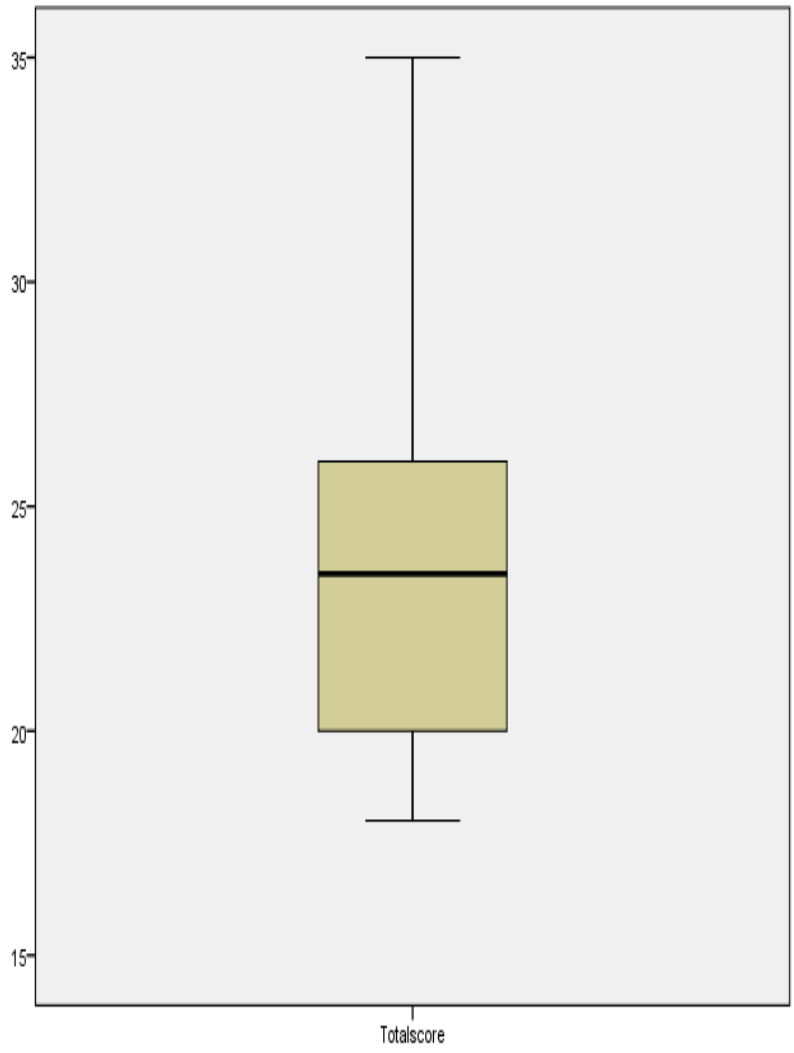
The total count varies from the minimum of 1000 cell /cumm to maximum of 42000 cells/cumm in the entire study group.

Figure: Box – Whisker Plot of acute physiology score



The acute physiology score varies from minimum of 5 to maximum of 33 among the study population. Also APS differs between normo and hypomagnesemic patients which is statistically significant.

Figure: Box – Whisker Plot of total score.



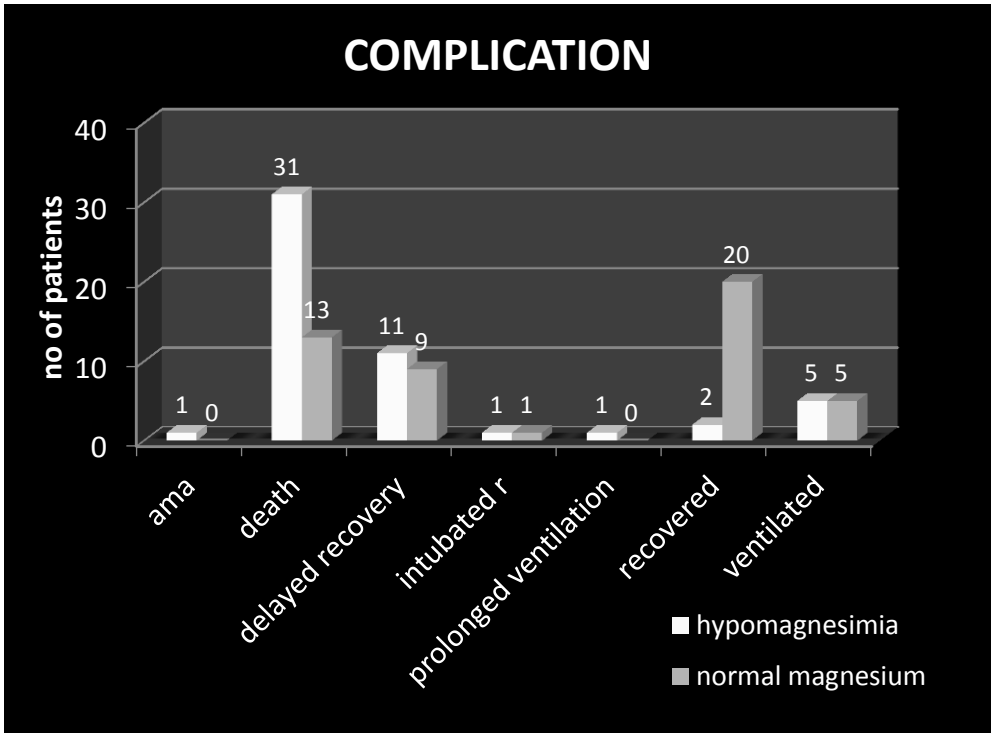
Total APACHE II score varies from maximum of 35 to minimum of 18 among the study group. It has statistical significance between normo and hypomagnesemic patients.

Table : Comparision of mean Hypomagnemia across study groups (N=100)

APS	Mean	Mean ± STD	Mean difference	95% CI		P value
				Lower	Upper	
Yes	22.44	22.44 ± 4.691	1.90	0.23690	3.56310	.026
No	20.54	20.54 ± 3.620				

Final outcome of my study

	hypomagnesimia	normal magnesium
AMA	1 (2%)	0
death	31 (59%)	13(27%)
delayed recovery	11(21%)	9 (19%)
intubated	6(12%)	6 (12%)
prolonged ventilation	1(2%)	0
recovered	2(4%)	20(42%)


COMPLICATION
no of patients
40
30
20
10
0
1
0
31
13
11
9
1
1
1
0
2
20
5
5
ama
death
delayed recovery
intubated r
prolonged ventilation
recovered
ventilated
hypomagnesimia
normal magnesium

DISCUSSION

In my study, 58% of critically ill patients who were admitted in IMCU, Stanley Medical college, had hypomagnesemia. 42% were normomagnesemic at the time of admission. The death rate was significant among hypomagnesemic patients (59%) when compared to normomagnesemic paients(27%). 21% of hypomagnesemic patients had delayed recovery, when compared to normomagnesemic patients (9%). The need for mechanical ventilation was equal among hypo and normomagnesemic individuals.

The rate of recovery also significantly high among normomagnesemic patients(42%), when compared to hypomagnesemic patients (4%). Also there is statistically significant difference in temperature(p0.0217), PCV (p 0.0105), serum sodium(p 0.0175) and APACHE II score(p 0.0001) between hypomagnesemic and normomagnesemic individuals.

H.S.Kiran et al had done a prospective study in 150 critically ill patients in an ICU of JSS Hospital, Mysore. Blood was taken for serum Mg and pertinent investigations within 24hrs of admission. Patient were monitored till discharge or death. On the day of admission 63% were normomagnesemic, 30% were hypomagnesemic and 7% had hypermagnesemia. Hypomagnesemic patients when compared with normomagnesemic individuals they had higher mortality rate (51% vs 36%), higher APACHE II score on admission (24.13 vs 22.47), need of ventilator support was more frequent (35% vs 17%).

Sunil kumar et al,conducted` a prospective observational study in 115 elderly patients of more than 60 years admitted in the Intensive Care Unit and correlated between Serum Magnesium levels and the duration of ICU stay, need for mechanical ventilation and its duration, and the final outcome about discharge or death.

They concluded that among the elderly patients admitted in ICU, 59.30% had low serum magnesium levels. Hypomagnesemic patients, when compared with normomagnesemic patients had no correlation with duration of ICU stay .But the necessity for mechanical ventilation, average duration of ventilation and death rate were higher in hypomagnesemic patients when compared to normomagnesemic individuals. Low serum magnesium levels were associated with mild increase in mortality rate. Need as well as the duration of mechanical ventilation were also higher , but they did not have statistical significance. Also the duration of ICU stay was not affected by hypomagnesemia. So serum magnesium level monitoring may have impact on prognostic and therapeutic implications especially in elderly patients.

Rubeiz et al conducted a prospective observational study in a total of 381 acutely ill patients admitted in an emergency department and consecutively shifted to medical ward and medical ICU of a tertiary care teaching hospital. On the day of admission concentration of serum magnesium and other metabolic variables were measured. Acute Physiology And Chronic health evaluation (APACHE II) scores were calculated for all patients. The mortality

rate was determined among normomagnesemic as well as hypomagnesemic patients.

In their study, both hypomagnesemic and normomagnesemic group of patients had comparable APACHE II scores and other metabolic variables. But the mortality rate for hypomagnesemic patients both in the ward and medical ICU was approximately twice ($p<.01$) when compared to normomagnesemic patients. Other metabolic abnormalities like hypokalemia and hypocalcemia had been observed equally in both hypomagnesemic and normomagnesemic patients. So they concluded that low serum magnesium level in acutely ill medical patients those admitted in both medical wards and ICU is associated with high mortality rate.

Soliman et al conducted prospective observational study in 446 patients admitted to a University hospital ICU over a period of 3 months. On the day of admission 18% had ionized hypomagnesemia, 14% had ionized hypermagnesemia and 68% had normal ionized magnesium levels. Length of the stay in ICU and mortality had no association with low serum magnesium level. But patients with low serum ionized magnesium had higher rate of septic shock (57% vs 11%, $p<0.01$) and high mortality rate (35% vs 12%, $p<0.01$). Low serum ionized magnesium has associated with diuretic use, increased incidence of sepsis and worse outcomes. So they concluded that monitoring of ionized magnesium levels may have prognostic as well as therapeutic implications.

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INSTITUTIONAL ETHICAL COMMITTEE, STANLEY MEDICAL COLLEGE, CHENNAI-1

Title of the Work : Serum Magnesium level in critically ill patients..

Principal Investigator : Dr. G Vijayalakshmi

Designation : PG, MD (General Medicine)

Department : Department of General Medicine
Government Stanley Medical College,
Chennai-01

The request for an approval from the Institutional Ethical Committee (IEC) was considered on the IEC meeting held on 24.03.2016 at the Council Hall, Stanley Medical College, Chennai-1 at 2PM

The members of the Committee, the secretary and the Chairman are pleased to approve the proposed work mentioned above, submitted by the principal investigator.

The Principal investigator and their team are directed to adhere to the guidelines given below:

1. You should inform the IEC in case of changes in study procedure, site investigator investigation or guide or any other changes.
2. You should not deviate from the area of the work for which you applied for ethical clearance.
3. You should inform the IEC immediately, in case of any adverse events or serious adverse reaction.
4. You should abide to the rules and regulation of the institution(s).
5. You should complete the work within the specified period and if any extension of time is required, you should apply for permission again and do the work.
6. You should submit the summary of the work to the ethical committee on completion of the work.

K Vasantha

MEMBER SECRETARY,
IEC, SMC, CHENNAI

MEMBER SECRETARY
ETHICAL COMMITTEE,
STANLEY MEDICAL COLLEGE
CHENNAI-600 001.

PROFORMA

Name :

Age /Sex:

Occupation:

Address with contact No:

Date of admission:

Date of discharge or death:

History:

Physical examination

General examination

Vitals

Systemic Examination

CVS

RS

Abdomen

CNS

APACHE II score

Investigations:

CBC, RFT

CHEST X RAY, ECG

Serum Electrolytes: Na, K, HCO3, Cl, Mg

Blood sugar

ABG

USG Abdomen

Other pertinent investigations

GOVT. STANLEY MEDICAL COLLEGE, CHENNAI – 600001

INFORMED CONSENT
SERUM MAGNESIUM LEVEL IN CRITICALLY ILL PATIENTS AT GOVERNMENT STANLEY HOSPITAL, CHENNAI.

நான் இந்த ஆராய்ச்சியில் விவரங்களை முற்றிலும் புரிந்து கொண்டேன். ஆய்வில் பங்கு எடுத்து போது, சாத்தியமான அபாயங்கள் மற்றும் பயன்களை பற்றி நான் அறிந்துள்ளேன்.

நான் எந்தவொரு வேளையிலும் ஆய்வில் இருந்து திரும்ப முடியும், அதன் பின்னர், நான் வழக்கம் போல் மருத்துவ சிகிச்சை பெற முடியும் என்று புரிந்துகொள்கிறேன்.

நான் ஆய்வில் பங்கு எடுத்து பணம் எதையும் பெற முடியாது என்று அறிந்துள்ளேன். இந்த ஆய்வின் முடிவுகள் எந்த மெடிக்கல் ஜர்னலில் வெளியிடப்பட இருந்தால் நான் எதிர்க்கவில்லை, என் தனிப்பட்ட அடையாளத்தை வெளிப்படுத்தப்பட்டு இருக்க கூடாது. நான் இந்த ஆய்வில் பங்கெடுப்பதன் மூலம் நான் என்ன செய்ய போகிறேன் என்று தெரியும்.நான் இந்த ஆய்வில் என் முழு ஒத்துழைப்பையும் கொடுப்பேன் என்று உறுதியளிக்கிறேன்.

தன்னார்வளர்

சாட்

பெயர் மற்றும் முகவரி பெயர்

மற்றும் முகவரி கையொப்பம் / விரல் ரேகை:

கையொப்பம்விரல்ரேகை:

ஆராய்ச்சியாளராக , கையொப்பம் மற்றும் தேதி

GOVT. STANLEY MEDICAL COLLEGE, CHENNAI – 600001

INFORMED CONSENT

SERUM MAGNESIUM LEVEL IN CRITICALLY ILL PATIENTS AT GOVERNMENT STANLEY HOSPITAL, CHENNAI.

Place of study: Govt. Stanley medical college, Chennai

I ……. have been informed about the details of the study in my own language.I have completely understood the details of the study. I am aware of the possible risks and benefits, while taking part in the study. I agree to collect samples of blood/saliva/urine/tissue if study needs. I understand that I can withdraw from the study at any point of time and even then, I can receive the medical treatment as usual. I understand that I will not get any money for taking part in the study.

I will not object if the results of this study are getting published in any medical journal, provided my personal identity is not revealed. I know what I am supposed to do by taking part in this study and I assure that I would extend my full cooperation for this study.

Volunteer:	Witness:
Name and address	Name and address
Signature/thumb impression	Signature/thumb impression

Investigator :

Signature and date

MASTER CHART

S.NO	AGE All	SEX	TEMP© All	HR All	MAP All	RR All	PaO2 All	Art PH All	Na All	K All	Creat All	PCV All	TC All	GCS	APS	CHP	Total score	S.Mg		
1	512	M	403	1202	602	301	651	7.420	1450	3.31	1.72	282	180001	2	19		19	1.8	Recovered	
2	665	M	380	602	1403	111	583	7.511	1282	4.50	1.82	272	110000	12	33		33	1.2	Death	
3	482	M	36.80	1282	1000	363	544	7.63	1350	4.80	1.20	420	102000	4	18	5	23	2.1	Recovered	
4	280	F	370	354	404	514	554	7.63	1410	3.90	0.80	440	98000	8	23		23	1.1	Ventilated	and recovered
5	210	F	38.61	820	672	220	780	7.460	1123	3.31	2.83	212	162001	0	13	5	18	1.5	Death	
6	502	F	38.20	1202	1433	453	621	7.360	1202	40	1.62	100	82000	3	18	5	23	1.5	Ventilated	
7	705	F	38.61	1603	672	321	701	7.252	1370	3.80	23	272	164001	3	24		24	1.2	Delay Rec	
8	603	F	403	1000	672	281	691	7.282	1522	63	0.90	310	189001	3	21	5	26	0.9	Death	
9	492	F	393	1463	1020	363	980	7.450	1282	3.90	1.10	292	281002	12	29		29	2.1	Death	
10	452	M	414	1603	1172	240	800	7.350	1232	5.10	0.80	350	220002	11	24		24	2.1	Recovered	

11	400	F	40.13	1080	464	321	671	7.23	1340	3.90	2.73	212	122000	3	20		20	2.2	Delay Rec	
12	140	F	393	1603	870	281	780	4.20	1360	3.90	0.50	84	245002	5	18		18	2	Recovered	
13	380	M	370	830	1132	353	603	7.430	1350	3.70	2.33	272	112000	3	16	5	21	0.9	Death	
14	665	M	403	1212	1202	301	860	7.410	1272	63	4.44	300	310002	3	26		26	1	Recovered	
15	705	F	37.20	1121	692	423	681	7.450	1350	4.80	1.62	282	250002		18		18	1.9	Recovered	
16	210	M	380	1503	770	363	1770	7.064	1522	31	0.80	300	160001	7	21		21	2.3	Recovered	
17	190	F	38.20	1513	960	261	850	7.153	1272	6.23	144	16.54	140000	0	20		20	2	Death	
18	665	F	380	980	900	281	780	7.350	1074	40	0.50	310	110000	5	15	5	20	1.2	Delay Rec	
19	553	M	35.61	800	780	281	900	7.360	1262	63	10.44	184	193001	3	22	5	27	0.8	Death	
20	452	M	403	1423	552	281	920	7.32	1420	6.63	5.14	440	245002	3	25		25	1.6	Delay Rec	
21	502	M	380	1102	503	251	603	7.322	1212	3.80	1.82	282	102000	0	19	5	24	2.1	Delay Rec	
22	472	M	38.10	1423	454	1654	554	7.330	1450	3.90	1.00	440	96000	3	20		20	2.5	Recovered	
23	603	F	403	443	1503	261	900	7.511	1440	4.80	1.92	450	88000	12	25		25	1.9	Death	

24	583	M	370	1603	454	281	701	7.322	1262	3.80	1.00	154	78000	3	23	5	28	0.9	Death	
25	685	F	38.71	1483	1282	363	681	7.292	1450	5.51	3.84	202	189001	0	25	5	30	1.3	Ventilated	
26	593	F	40.63	1523	1000	321	1060	7.450	1292	5.61	1.62	282	261002	0	19		19	2.4	Recovered	
27	826	M	37.90	1322	1212	383	691	7.370	1272	4.70	1.72	242	291002	4	26		26	2	Delay Rec	
28	553	M	380	1503	1122	383	583	7.360	1350	50	2.23	272	110000	3	22	5	27	0.9	Death	
29	623	F	38.61	1262	652	261	1050	7.40	1242	4.80	64	282	226002	3	22		22	1.1	Recovered	
30	655	M	37.90	1102	980	383	701	7.450	1380	40	44	282	197001	0	18		18	2.1	Recovered	
31	603	M	360	1513	1282	423	534	7.340	1310	4.10	5.14	310	270002	3	24		24	0.6	Prolonged ventilation	
32	633	F	36.20	1382	1102	321	1050	7.322	1193	5.61	4.14	282	151001	0	21		21	1.5	Delay Rec	
33	553	M	370	1583	484	291	621	7.302	1183	3.60	1.20	184	78000	4	25	5	30	0.8	Death	
34	705	F	37.60	1483	552	331	583	7.322	1282	3.70	1.82	292	150001	3	26	5	31	0.9	Death	
35	553	F	36.90	1232	622	291	603	7.243	1410	4.50	1.20	481	189001	3	19	5	24	1.2	Ventilated	
36	350	F	37.90	1382	464	383	583	7.350	1460	4.10	0.80	272	171001	0	15	5	20	2.2	Recovered	

37	655	F	40.13	1623	1060	341	1080	7.322	1360	3.80	5.24	272	350002	3	25		25	0.9	Death	
38	482	M	380	1262	682	261	800	7.340	1222	3.90	10	272	152001	6	18	5	23	1.1	Delay Rec	
39	380	F	351	463	552	443	554	7.312	1390	4.10	0.90	360	140000	11	26		26	2.2	Ventilated	
40	250	M	38.81	1362	1020	363	1100	7.350	1282	4.80	2.03	400	320002	12	25		25	2.1	*Death*	
41	725	F	37.60	543	1323	261	1080	7.312	1272	6.13	7.54	272	110000	0	25		25	1.1	AMA	
42	756	M	38.30	1623	1523	373	554	7.330	1360	4.10	1.62	292	74000	0	23		23	1.7	Death	
43	360	M	40.23	1593	522	423	920	7.282	1272	4.20	1.52	310	228002	0	19		19	2.4	Recovered	
44	655	M	39.83	1413	502	383	1020	7.511	1320	5.61	3.43	272	310002	6	31		31	0.7	Death	
45	250	M	38.20	682	692	180	1100	7.460	1193	4.40	2.63	242	75000	12	24	5	29	0.6	Death	
46	512	M	360	1232	800	261	920	7.360	1202	3.90	1.52	262	93000	7	18	5	23	1	Death	
47	400	F	37.80	1723	562	413	554	7.330	1292	50	1.10	292	151001	3	20		20	1.9	Ventilated	
48	603	M	38.71	1362	850	261	1060	7.312	1300	4.50	3.23	242	261002	3	19		19	2	Delay Rec	
49	410	M	40.13	1683	1060	514	603	7.312	1350	4.40	1.52	320	234002	0	19		19	2.1	Recovered	

50	290	F	380	1182	1563	301	1080	7.23	1360	5.51	5.14	212	260002	7	25		25	1.1	Delay Rec	
51	452	F	35.91	1583	462	271	780	7.340	1380	40	1.10	124	10004	5	22		22	1.3	Death	
52	210	M	393	1633	1080	363	980	7.40	1282	4.30	1.52	272	282002	9	26		26	0.9	Death	
53	603	M	414	463	1583	251	900	7.511	1460	4.80	1.62	360	85000	12	27		27	2	Death	
54	230	M	38.61	1362	454	261	750	7.312	1292	3.90	10	330	221002	9	23		23	1.5	Death	
55	705	F	370	1453	1040	423	504	7.340	1360	4.20	1.20	272	140000	8			25	2.1	Ventilated	
56	482	M	36.70	1513	464	363	691	7.40	1350	4.60	2.13	330	112000	3	19		19	2.3	Delay Rec	
57	270	M	39.23	1683	562	373	890	7.322	1380	4.20	1.52	241	270002	6	24		24	1.1	Delay Rec	
58	583	M	37.70	1362	562	271	701	7.322	1360	50	4.54	212	280002	7	26	5	31	0.7	Death	
59	472	M	393	1523	900	423	583	7.322	1480	50	23	390	310002	4	25		25	1.1	Death	
60	300	M	39.53	1443	1050	504	691	7.340	1450	4.40	10	350	420004	3	18		18	2.3	Recovered	
61	400	M	39.73	1553	652	363	1080	7.40	1380	5.51	44	320	280002		18		18	2.1	Delay Rec	
62	685	M	380	1352	1060	423	544	7.440	1460	3.90	1.30	461	220002	6	23		23	1.8	Ventilated	

63	482	M	370	1413	552	383	524	7.350	1390	50	1.20	330	72000	7	21		21	2.4	Recovered
64	623	M	36.50	800	760	261	1080	7.450	1193	3.60	3.84	282	55000	11	5		29	1.1	Death
65	725	F	380	720	1503	111	1120	7.330	1460	4.80	1.52	330	110000	12	23		23	1.8	Death
66	553	M	38.20	1322	552	261	900	7.340	1282	4.10	1.52	330	150001	0	13	5	18	1.9	Recovered
67	603	F	360	1493	522	363	603	7.350	1350	3.90	1.52	272	72000	3	21	5	26	1.1	Death
68	695	M	38.10	1423	1583	363	651	7.322	1380	5.71	64	212	81000	3	27		27	0.9	Death
69	452	M	39.23	1513	682	363	990	7.450	1460	5.10	1.62	272	260002	0	19		19	2.5	Recovered
70	482	M	38.40	1693	484	524	554	7.480	1360	4.80	1.20	242	120000	3	22		22	1.9	Death
71	522	M	37.50	1102	1282	251	1080	7.262	1370	5.71	84	262	210002	0	18		18	2	Recovered
72	370	M	37.40	1262	682	261	1100	7.340	1282	3.70	3.64	242	78000	7	20	5	25	1.1	Death
73	542	F	37.90	1282	682	281	920	7.340	1292	5.10	23	292	91000	3	19		19	1.9	Recovered
74	350	F	37.90	1713	692	261	1010	7.360	1380	4.10	1.52	272	61000	8	18		18	2.3	Delay Rec
75	482	M	39.23	1683	1080	423	603	7.312	1380	4.10	1.20	292	410004	0	22		22	1.9	Ventilated

76	603	F	38.91	1413	622	281	1210	7.340	1350	3.70	1.52	272	320002	3	19	5	24	1.4	Delay Rec	
77	300	M	414	1553	1020	383	583	7.322	1420	4.50	1.00	360	420004	0	19		19	2.2	Death	
78	430	M	37.10	324	484	261	603	7.40	1450	4.10	1.10	282	101000	6	20		20	2.3	Death	
79	756	F	37.60	1713	424	363	603	7.430	1380	4.60	1.52	292	72000	3	26		26	0.8	Death	
80	583	M	38.10	1282	522	261	980	7.410	1282	2.82	1.30	184	12002	3	21	5	26	1	Death	
81	270	M	341	682	1563	271	1080	7.322	1292	40	1.52	154	14502	6	25	5	30	0.9	Death	
82	430	M	37.50	1382	682	281	603	7.420	1360	3.90	0.90	292	97000	3	13	5	18	2	Delay Rec	
83	643	M	38.81	1322	672	363	1020	7.322	1292	4.50	1.52	282	321002	3	24		24	1.9	Recovered	
84	230	F	40.13	1653	444	443	1100	7.51	1292	4.80	1.00	262	410004	6	28		28	2.2	Death	
85	573	M	393	1493	522	281	900	7.322	1380	4.10	1.00	272	261002	3	21		21	1.8	Death	
86	633	F	37.50	453	1423	101	1200	7.450	1460	3.90	1.52	320	49000	12	24		24	1.6	Death	
87	512	M	36.20	1624	424	341	720	7.420	1292	3.60	1.20	184	71000	6	23	5	28	0.8	Death	
88	360	M	38.50	1483	1050	524	524	7.51	1460	3.90	0.80	461	92000	7	20	5	25	1.8	Intubated r	

89	340	M	38.20	1814	454	261	593	7.330	1450	4.50	1.10	330	71000	3	15	5	18	0.9	Delay Rec	
90	563	M	38.10	*1423*	1030	483	593	7.480	1480	4.90	1.52	184	40000		18	5	23	0.9	ventilated	
91	593	M	393	1513	1020	433	583	7.322	1380	4.20	1.40	330	410004	0	21		21	0.9	Delay Rec	
92	603	F	38.20	1122	760	383	1080	7.51	1292	4.60	1.52	184	151001	12	30	5	35	0.7	Death	
93	553	F	38.20	1453	1102	363	1100	7.243	1380	5.61	4.14	292	180001	3	25		25	1.2	Death	
94	502	M	370	1202	682	363	691	7.340	1183	40	1. 62	184	15002	7	26		26	2.2	Death	
95	482	F	38.61	1623	700	281	980	7.322	1292	3.50	44	262	178001	3	21	5	26	1.1	Death	
96	340	F	393	1433	720	363	681	7.340	1292	3.60	1.52	262	286002	3	21	5	26	1.7	Delay Rec	
97	553	M	370	1382	1020	514	554	7.450	1450	3.90	1.52	282	161001	0	18	5	23	2	Death	
98	655	M	393	1763	562	363	651	7.51	1300	40	23	282	330002	6	26		26	0.8	Intubated r	
99	553	F	38.10	1282	454	261	1080	7.410	1320	3.70	1.52	292	71000		14	5	19	2.3	Recovered	
100	563	M	38.61	1292	622	261	1100	7.340	1292	3.60	33	292	280002	3	18		18	2.1	Delay Rec	

PATIENTS WITH HYPOMAGNESIMIA

AGE	All	SEX	TEMP©	All	HR	All	MAP	All	RR	All	PaO2	All	Art PH	All	Na	All	K	All	Creat	All	PCV	All	TC	All	GCS	APS	CHP	Total score	S.Mg	
66	5	M	38	0	60	2	140	3	11	1	58	3	7.51	1	128	2	4.5	0	1.8	2	27	2	11000	0	12	33		33	1.2	Death
28	0	F	37	0	35	4	40	4	51	4	55	4	7.6	3	141	0	3.9	0	0.8	0	44	0	9800	0	8	23		23	1.1	Ventilated
21	0	F	38.6	1	82	0	67	2	22	0	78	0	7.46	0	112	3	3.3	1	2.8	3	21	2	16200	1	0	13	5	18	1.5	Death
50	2	F	38.2	0	120	2	143	3	45	3	62	1	7.36	0	120	2	4	0	1.6	2	10	0	8200	0	3	18	5	23	1.5	Ventilated
70	2	F	38.6	1	160	3	67	2	32	1	70	1	7.25	2	137	0	3.8	0	2	3	27	2	16400	1	3	24		24	1.2	Delay Rec
60	3	F	40	3	100	0	67	2	28	1	69	1	7.28	2	152	2	6	3	0.9	0	31	0	18900	1	3	21	5	26	0.9	Death
38	0	M	37	0	83	0	113	2	35	3	60	3	7.43	0	135	0	3.7	0	2.3	3	27	2	11200	0	3	16	5	21	0.9	Death
66	5	M	40	3	121	2	120	2	30	1	86	0	7.41	0	127	2	6	3	4.4	4	30	0	31000	2	3	26		26	1	Recovered
66	5	F	38	0	98	0	90	0	28	1	78	0	7.35	0	107	4	4	0	0.5	0	31	0	11000	0	5	15	5	20	1.2	Delay Rec
55	3	M	35.6	1	80	0	78	0	28	1	90	0	7.36	0	126	2	6	3	10.4	4	18	4	19300	1	3	22	5	27	0.8	Death
45	2	M	40	3	142	3	55	2	28	1	92	0	7.3	2	142	0	6.6	3	5.1	4	44	0	24500	2	3	25		25	1.6	Delay Rec
58	3	M	37	0	160	3	45	4	28	1	70	1	7.32	2	126	2	3.8	0	1	0	15	4	7800	0	3	23	5	28	0.9	Death
68	5	F	38.7	1	148	3	128	2	36	3	68	1	7.29	2	145	0	5.5	1	3.8	4	20	2	18900	1	0	25	5	30	1.3	Ventilated
55	3	M	38	0	150	3	112	2	38	3	58	3	7.36	0	135	0	5	0	2.2	3	27	2	11000	0	3	22	5	27	0.9	Death

62	3	F	38.6	1	126	2	65	2	26	1	105	0	7.4	0	124	2	4.8	0	6	4	28	2	22600	2	3	22		22	1.1	Recovered
60	3	M	36	0	151	3	128	2	42	3	53	4	7.34	0	131	0	4.1	0	5.1	4	31	0	27000	2	3	24		24	0.6	Prolonged ventilation
63	3	F	36.2	0	138	2	110	2	32	1	105	0	7.32	2	119	3	5.6	1	4.1	4	28	2	15100	1	0	21		21	1.5	Delay Rec
55	3	M	37	0	158	3	48	4	29	1	62	1	7.3	2	118	3	3.6	0	1.2	0	18	4	7800	0	4	25	5	30	0.8	Death
70	5	F	37.6	0	148	3	55	2	33	1	58	3	7.32	2	128	2	3.7	0	1.8	2	29	2	15000	1	3	26	5	31	0.9	Death
55	3	F	36.9	0	123	2	62	2	29	1	60	3	7.24	3	141	0	4.5	0	1.2	0	48	1	18900	1	3	19	5	24	1.2	Ventilated
65	5	F	40.1	3	162	3	106	0	34	1	108	0	7.32	2	136	0	3.8	0	5.2	4	27	2	35000	2	3	25		25	0.9	Death
48	2	M	38	3	126	2	68	2	26	1	80	0	7.34	0	122	2	3.9	0	1	0	27	2	15200	1	6	18	5	23	1.1	Delay Rec
72	5	F	37.6	0	54	2	132	3	26	1	108	0	7.31	2	127	2	6.1	3	7.5	4	27	2	11000	0	0	25		25	1.1	AMA
75	6	M	38.3	0	162	3	152	3	37	3	55	4	7.33	0	136	0	4.1	0	1.6	2	29	2	7400	0	0	23		23	1.7	Death
65	5	M	39.8	3	141	3	50	2	38	3	102	0	7.51	1	132	0	5.6	1	3.4	3	27	2	31000	2	6	31		31	0.7	Death
25	0	M	38.2	0	68	2	69	2	18	0	110	0	7.46	0	119	3	4.4	0	2.6	3	24	2	7500	0	12	24	5	29	0.6	Death
51	2	M	36	0	123	2	80	0	26	1	92	0	7.36	0	120	2	3.9	0	1.5	2	26	2	9300	0	7	18	5	23	1	Death
29	0	F	38	0	118	2	156	3	30	1	108	0	7.2	3	136	0	5.5	1	5.1	4	21	2	26000	0	7	25		25	1.1	Delay Rec
45	2	F	35.9	1	158	3	46	2	27	1	78	0	7.34	0	138	0	4	0	1.1	0	12	4	1000	4	5	22		22	1.3	Death
21	0	M	39	3	163	3	108	0	36	3	98	0	7.4	0	128	2	4.3	0	1.5	2	27	2	28200	2	9	26		26	0.9	Death
23	0	M	38.6	1	136	2	45	4	26	1	75	0	7.31	2	129	2	3.9	0	1	0	33	0	22100	2	9	23		23	1.5	Death

27	0	M	39.2	3	168	3	56	2	37	3	89	0	7.32	2	138	0	4.2	0	1.5	2	24	1	27000	2	6	24		24	1.1	Delay Rec
58	3	M	37.7	0	136	2	56	2	27	1	70	1	7.32	2	136	0	5	0	4.5	4	21	2	28000	2	7	26	5	31	0.7	Death
47	2	M	39	3	152	3	90	0	42	3	58	3	7.32	2	148	0	5	0	2	3	39	0	31000	2	4	25		25	1.1	Death
62	3	M	36.5	0	80	0	76	0	26	1	108	0	7.45	0	119	3	3.6	0	3.8	4	28	2	5500	0	11	5		29	1.1	Death
60	3	F	36	0	149	3	52	2	36	3	60	3	7.35	0	135	0	3.9	0	1.5	2	27	2	7200	0	3	21	5	26	1.1	Death
69	5	M	38.1	0	142	3	158	3	36	3	65	1	7.32	2	138	0	5.7	1	6	4	21	2	8100	0	3	27		27	0.9	Death
37	0	M	37.4	0	126	2	68	2	26	1	110	0	7.34	0	128	2	3.7	0	3.6	4	24	2	7800	0	7	20	5	25	1.1	Death
60	3	F	38.9	1	141	3	62	2	28	1	121	0	7.34	0	135	0	3.7	0	1.5	2	27	2	32000	2	3	19	5	24	1.4	Delay Rec
75	6	F	37.6	0	171	3	42	4	36	3	60	3	7.43	0	138	0	4.6	0	1.5	2	29	2	7200	0	3	26		26	0.8	Death
58	3	M	38.1	0	128	2	52	2	26	1	98	0	7.41	0	128	2	2.8	2	1.3	0	18	4	1200	2	3	21	5	26	1	Death
27	0	M	34	1	68	2	156	3	27	1	108	0	7.32	2	129	2	4	0	1.5	2	15	4	1450	2	6	25	5	30	0.9	Death
63	3	F	37.5	0	45	3	142	3	10	1	120	0	7.45	0	146	0	3.9	0	1.5	2	32	0	4900	0	12	24		24	1.6	Death
51	2	M	36.2	0	162	4	42	4	34	1	72	0	7.42	0	129	2	3.6	0	1.2	0	18	4	7100	0	6	23	5	28	0.8	Death
34	0	M	38.2	0	181	4	45	4	26	1	59	3	7.33	0	145	0	4.5	0	1.1	0	33	0	7100	0	3	15	5	18	0.9	Delay Rec
56	3	M	38.1	0	*142*	*3*	103	0	48	3	59	3	7.48	0	148	0	4.9	0	1.5	2	18	4	4000	0		18	5	23	0.9	ventilated
59	3	M	39	3	151	3	102	0	43	3	58	3	7.32	2	138	0	4.2	0	1.4	0	33	0	41000	4	0	21		21	0.9	Delay Rec
60	3	F	38.2	0	112	2	76	0	38	3	108	0	7.5	1	129	2	4.6	0	1.5	2	18	4	15100	1	12	30	5	35	0.7	Death
55	3	F	38.2	0	145	3	110	2	36	3	110	0	7.24	3	138	0	5.6	1	4.1	4	29	2	18000	1	3	25		25	1.2	Death

48	2	F	38.6	1	162	4	70	0	28	1	98	0	7.32	2	129	2	3.5	0	4	4	26	2	17800	1	3	21	5	26	1.1	Death
34	0	F	39	3	143	3	72	0	36	3	68	1	7.34	0	129	2	3.6	0	1.5	2	26	2	28600	2	3	21	5	26	1.7	Delay Rec
65	5	M	39	3	176	3	56	2	36	3	65	1	7.5	1	130	0	4	0	2	3	28	2	33000	2	6	26		26	0.8	Intubated r

PATIENTS WITH NORMOMAGNESEMIA

AGE	All	SEX	TEMP©	All	HR	All	MAP	All	RR	All	Po2	All	Art PH	All	Na	All	K	All	Creat	All	PCV	All	TC	All	GCS	APS	CHP	Total score	S.Mg	
51	2	M	40	3	120	2	60	2	30	1	65	1	7.42	0	145	0	3.3	1	1.7	2	28	2	18000	1	2	19		19	1.8	Recovered
48	2	M	36.8	0	128	2	100	0	36	3	54	4	7.6	3	135	0	4.8	0	1.2	0	42	0	10200	0	4	18	5	23	2.1	Recovered
49	2	F	39	3	146	3	102	0	36	3	98	0	7.45	0	128	2	3.9	0	1.1	0	29	2	28100	2	12	29		29	2.1	Death
45	2	M	41	4	160	3	117	2	24	0	80	0	7.35	0	123	2	5.1	0	0.8	0	35	0	22000	2	11	24		24	2.1	Recovered
40	0	F	40.1	3	108	0	46	4	32	1	67	1	7.2	3	134	0	3.9	0	2.7	3	21	2	12200	0	3	20		20	2.2	Delay Rec
14	0	F	39	3	160	3	87	0	28	1	78	0	4.2	0	136	0	3.9	0	0.5	0	8	4	24500	2	5	18		18	2	Recovered
70	5	F	37.2	0	112	1	69	2	42	3	68	1	7.45	0	135	0	4.8	0	1.6	2	28	2	25000	2		18		18	1.9	Recovered
21	0	M	38	0	150	3	77	0	36	3	177	0	7.06	4	152	2	3	1	0.8	0	30	0	16000	1	7	21		21	2.3	Recovered
19	0	F	38.2	0	151	3	96	0	26	1	85	0	7.15	3	127	2	6.2	3	14	4	16.5	4	14000	0	0	20		20	2	Death
50	2	M	38	0	110	2	50	3	25	1	60	3	7.32	2	121	2	3.8	0	1.8	2	28	2	10200	0	0	19	5	24	2.1	Delay Rec
47	2	M	38.1	0	142	3	45	4	165	4	55	4	7.33	0	145	0	3.9	0	1	0	44	0	9600	0	3	20		20	2.5	Recovered
60	3	F	40	3	44	3	150	3	26	1	90	0	7.51	1	144	0	4.8	0	1.9	2	45	0	8800	0	12	25		25	1.9	Death
59	3	F	40.6	3	152	3	100	0	32	1	106	0	7.45	0	129	2	5.6	1	1.6	2	28	2	26100	2	0	19		19	2.4	Recovered

82	6	M	37.9	0	132	2	121	2	38	3	69	1	7.37	0	127	2	4.7	0	1.7	2	24	2	29100	2	4	26		26	2	Delay Rec
65	5	M	37.9	0	110	2	98	0	38	3	70	1	7.45	0	138	0	4	0	4	4	28	2	19700	1	0	18		18	2.1	Recovered
35	0	F	37.9	0	138	2	46	4	38	3	58	3	7.35	0	146	0	4.1	0	0.8	0	27	2	17100	1	0	15	5	20	2.2	Recovered
38	0	F	35	1	46	3	55	2	44	3	55	4	7.31	2	139	0	4.1	0	0.9	0	36	0	14000	0	11	26		26	2.2	Ventilated
25	0	M	38.8	1	136	2	102	0	36	3	110	0	7.35	0	128	2	4.8	0	2	3	40	0	32000	2	12	25		25	2.1	*Death*
36	0	M	40.2	3	159	3	52	2	42	3	92	0	7.28	2	127	2	4.2	0	1.5	2	31	0	22800	2	0	19		19	2.4	Recovered
40	0	F	37.8	0	172	3	56	2	41	3	55	4	7.33	0	129	2	5	0	1.1	0	29	2	15100	1	3	20		20	1.9	Ventilated
60	3	M	38.7	1	136	2	85	0	26	1	106	0	7.31	2	130	0	4.5	0	3.2	3	24	2	26100	2	3	19		19	2	Delay Rec
41	0	M	40.1	3	168	3	106	0	51	4	60	3	7.31	2	135	0	4.4	0	1.5	2	32	0	23400	2	0	19		19	2.1	Recovered
60	3	M	41	4	46	3	158	3	25	1	90	0	7.51	1	146	0	4.8	0	1.6	2	36	0	8500	0	12	27		27	2	Death
70	5	F	37	0	145	3	104	0	42	3	50	4	7.34	0	136	0	4.2	0	1.2	0	27	2	14000	0	8			25	2.1	Ventilated
48	2	M	36.7	0	151	3	46	4	36	3	69	1	7.4	0	135	0	4.6	0	2.1	3	33	0	11200	0	3	19		19	2.3	Delay Rec
30	0	M	39.5	3	144	3	105	0	50	4	69	1	7.34	0	145	0	4.4	0	1	0	35	0	42000	4	3	18		18	2.3	Recovered
40	0	M	39.7	3	155	3	65	2	36	3	108	0	7.4	0	138	0	5.5	1	4	4	32	0	28000	2		18		18	2.1	Delay Rec
68	5	M	38	0	135	2	106	0	42	3	54	4	7.44	0	146	0	3.9	0	1.3	0	46	1	22000	2	6	23		23	1.8	Ventilated
48	2	M	37	0	141	3	55	2	38	3	52	4	7.35	0	139	0	5	0	1.2	0	33	0	7200	0	7	21		21	2.4	Recovered
72	5	F	38	0	72	0	150	3	11	1	112	0	7.33	0	146	0	4.8	0	1.5	2	33	0	11000	0	12	23		23	1.8	Death
55	3	M	38.2	0	132	2	55	2	26	1	90	0	7.34	0	128	2	4.1	0	1.5	2	33	0	15000	1	0	13	5	18	1.9	Recovered

45	2	M	39.2	3	151	3	68	2	36	3	99	0	7.45	0	146	0	5.1	0	1.6	2	27	2	26000	2	0	19		19	2.5	Recovered
48	2	M	38.4	0	169	3	48	4	52	4	55	4	7.48	0	136	0	4.8	0	1.2	0	24	2	12000	0	3	22		22	1.9	Death
52	2	M	37.5	0	110	2	128	2	25	1	108	0	7.26	2	137	0	5.7	1	8	4	26	2	21000	2	0	18		18	2	Recovered
54	2	F	37.9	0	128	2	68	2	28	1	92	0	7.34	0	129	2	5.1	0	2	3	29	2	9100	0	3	19		19	1.9	Recovered
35	0	F	37.9	0	171	3	69	2	26	1	101	0	7.36	0	138	0	4.1	0	1.5	2	27	2	6100	0	8	18		18	2.3	Delay Rec
48	2	M	39.2	3	168	3	108	0	42	3	60	3	7.31	2	138	0	4.1	0	1.2	0	29	2	41000	4	0	22		22	1.9	Ventilated
30	0	M	41	4	155	3	102	0	38	3	58	3	7.32	2	142	0	4.5	0	1	0	36	0	42000	4	0	19		19	2.2	Death
43	0	M	37.1	0	32	4	48	4	26	1	60	3	7.4	0	145	0	4.1	0	1.1	0	28	2	10100	0	6	20		20	2.3	Death
43	0	M	37.5	0	138	2	68	2	28	1	60	3	7.42	0	136	0	3.9	0	0.9	0	29	2	9700	0	3	13	5	18	2	Delay Rec
64	3	M	38.8	1	132	2	67	2	36	3	102	0	7.32	2	129	2	4.5	0	1.5	2	28	2	32100	2	3	24		24	1.9	Recovered
23	0	F	40.1	3	165	3	44	4	44	3	110	0	7.5	1	129	2	4.8	0	1	0	26	2	41000	4	6	28		28	2.2	Death
57	3	M	39	3	149	3	52	2	28	1	90	0	7.32	2	138	0	4.1	0	1	0	27	2	26100	2	3	21		21	1.8	Death
36	0	M	38.5	0	148	3	105	0	52	4	52	4	7.5	1	146	0	3.9	0	0.8	0	46	1	9200	0	7	20	5	25	1.8	Intubated r
50	2	M	37	0	120	2	68	2	36	3	69	1	7.34	0	118	3	4	0	1. 6	2	18	4	1500	2	7	26		26	2.2	Death
55	3	M	37	0	138	2	102	0	51	4	55	4	7.45	0	145	0	3.9	0	1.5	2	28	2	16100	1	0	18	5	23	2	Death
55	3	F	38.1	0	128	2	45	4	26	1	108	0	7.41	0	132	0	3.7	0	1.5	2	29	2	7100	0		14	5	19	2.3	Recovered
56	3	M	38.6	1	129	2	62	2	26	1	110	0	7.34	0	129	2	3.6	0	3	3	29	2	28000	2	3	18		18	2.1	Delay Rec

ABBREVIATIONS

Temp	-	Temperature
HR	-	Heart Rate
MAP	-	Mean Arterial Pressure
RR	-	Respiratory Rate
Na	-	Sodium
K	-	Potassium
Mg	-	Magnesium
PCV	-	Packed Cell Volume
TC	-	Total Count
GCS	-	Glascow Coma Scale
A II	-	APACHE II SCORE
AMA	-	Against Medical Advice